

# PRELIMINARY ENGINEERING REPORT

## GRAND AVENUE STREET & SIDEWALK EXTENSION WORTHINGTON, MINNESOTA

6-3-15

Project No. 14-16841



I+S GROUP

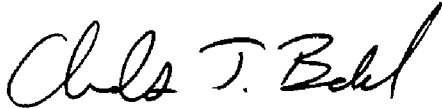
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# I+S GROUP

## Signature Sheet

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I HEREBY CERTIFY THAT THIS REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.



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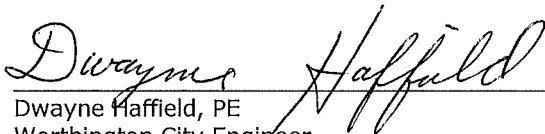
Charles J. Brandel, PE  
Project Engineer  
Reg. No. 43359

I+S Group, Inc.  
115 East Hickory Street, Suite 300  
Mankato, Minnesota 56001-3785

### **Grand Avenue Street & Sidewalk Extension Worthington, Minnesota**

**Engineer's Project Number: 14-16841**

Dated this 3rd day of June 2015



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Dwayne Haffield, PE  
Worthington City Engineer  
Reg. No. 15010

City of Worthington  
P.O. Box 279  
Worthington, MN 56187

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## **Introduction**

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I+S Group (ISG) was contacted to complete a Preliminary Engineering Report and Hydrology Report for the Grand Avenue Street & Sidewalk Extension north of Oxford Street; see Appendix A for a site location map. In prior improvements, sanitary sewer, storm sewer, and watermain were constructed in this area for the future expansion of Grand Avenue. Along with the storm sewer construction, a regional storm water retention pond was constructed to support the future development of approximately 28 acres of land.

In 2013, the Minnesota Pollution Control Agency (MPCA) raised the standards for detaining runoff from ½-inch to 1-inch for the newly created impervious area. The National Oceanic and Atmospheric Association (NOAA) has also updated the rainfall frequency curves as part of Atlas 14. NOAA's Atlas 14 raised the 10-year precipitation frequency estimate from 4.2 inches to 4.46 inches and the 100-year precipitation frequency estimate from 6.0 to 7.44 inches. The previous Storm Water Report was completed prior to the MPCA and NOAA Atlas 14 changes.

This report has been prepared pursuant to Council Resolution, dated April 27, 2015, Declaring Adequacy of Petition and Ordering the Preparation of Feasibility Report on the Proposed Grand Avenue Street Extension and Council Resolution, dated April 27, 2015, Ordering Preparation of Feasibility Report on the Proposed Sidewalk Improvement.

## **Project Need**

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The City received an adequate petition for the extension of Grand Avenue from the north end of the existing Grand Avenue, (approximately 200 feet north of Oxford Street), to the north line of the South Half of the Southwest Quarter of Section 13, Township 102 North, Range 40 West. In order to address the City's standards pertaining to walks and the City's Complete Street Policy, the City Council initiated improvement of Grand Avenue from Oxford Street to the same north line of the South Half of the Southwest Quarter of Section 13 by installation of walks.

The street extension will include paving Grand Avenue, curb and gutter construction, catch basins, and minor watermain and sanitary sewer adjustments. The sidewalk improvement is proposed to include 4-foot concrete walks and/or a 10-foot multi-use trail. Due to the noted adjustments to the MPCA and NOAA Atlas 14 standards, the street expansion will also include the expansion of the existing regional pond in order to satisfy permitting requirements for the proposed street improvement; see the Storm Water Report in Appendix C for more information on the pond expansion.

The improvements will benefit the abutting properties. The expansion of the regional pond may also limit the need for any separate storm water treatment by any future development along the proposed Grand Avenue and Cecilee Street. The expansion of the regional pond is proposed for this drainage area rather than requiring additional site specific treatment because of the linear nature of the remaining land to be developed and because the pond expansion is feasible. A need for additional on-site treatment may be required on any given site due to soil types and/or nature of the development.

## **Design**

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As previously described above, the watermain, sanitary sewer, and storm sewer have already been constructed as part of previous public improvements. With the utilities and drainage facilities already in place, the design of the Grand Avenue Street & Sidewalk Extensions are controlled by this existing infrastructure.

The plan as originally developed in 2009 was to eventually construct Grand Avenue as a 44-foot wide street, face-to-face, that widened out closer to Oxford Street. The revised cross-section option now being proposed includes a 40 foot street width. The 40 foot width reflects more contemporary street design concepts and provides for two 12' driving lanes and two 8 foot parking lanes rather than 10

foot parking lanes. The narrower street width leaves additional room for consideration of off street and pedestrian and bicycle facilities. Although the City's Active Living Plan is not complete, progress to date is leading toward a recommendation that key pedestrian/bikeway corridors be established and classified. Early work on classifying corridors indicates that Grand Avenue may serve as a secondary/neighborhood route. This designation gives priority to providing pedestrian and bikeway facilities. On-street bike lanes could be suitable in this corridor given no special circumstances, however, the existing configuration of driving and turning lanes near Oxford Street makes it impractical to use such bike lanes on the subject segment of Grand Avenue. To provide appropriate pedestrian and bicycle facilities it is recommended that both a 4-foot walk on the west side of Grand Avenue and a 10-foot wide multi-use trail on the east side of Grand Avenue be provided.

Near the intersection of Oxford Street and Grand Avenue, the existing curb and gutter will be replaced to fit the new 4-foot walk and 10-foot multi-use trail and accommodate for the American Disability Act (ADA) standards for pedestrian ramps. A more pedestrian friendly crossing will also be constructed crossing Grand Avenue on the north side of Oxford Street, with a pedestrian safety island constructed within the existing concrete median.

Also, as part of the 2009 utility extension plan, a 1.32 acre regional retention pond was constructed to control storm water runoff into the city storm sewer. As part of the Grand Avenue Street & Sidewalk Extension plan, it was calculated that the pond will need to be expanded to approximately 1.96 acres to accommodate the changes in the MPCA requirements and new NOAA Atlas 14 rainfall-frequency data. More information related to the pond expansion and storm drainage plan can be found in the Storm Water Report in Appendix C.

Both concrete and bituminous pavements are being presented in this report for consideration. The longevity of concrete typically far exceeds that of a bituminous surface; however, the projected project timeline would likely be extended as compared to a bituminous pavement construction. Whereas the costs presented in this report are based on bids received for the Grand Avenue project proposed last year, further alternate pricing could be considered unnecessary to make a determination as to the pavement type to be used for the proposed improvement.

## **Costs and Financing**

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### ***Street Extension***

The total estimated cost of the street extension, including engineering and contingencies, is \$875,000 for the concrete pavement alternative and \$727,000 for the bituminous pavement alternative. These totals include those costs associated with the storm sewer pond modifications and catch basin installation estimated to be between \$230,750 and \$239,265. It is anticipated that the necessary land for the storm water pond will be acquired by easement at no cost.

The properties abutting Grand Avenue are zoned residential. Per the assessment ordinance, only those costs of the project equaling that which would be incurred for construction of a residential street are to be assessed to residential properties. The estimated costs for construction of the Grand Avenue extension as a 36-foot wide residential street is \$443,250 for the concrete pavement alternative and \$337,575 for the bituminous pavement alternative. The costs for the additional width and pavement thickness will be a non-assessable City share. The following table provides a summary of the estimated costs, assessments, and City share for the proposed street extension.

	<u>CONCRETE</u>	<u>BITUMINOUS</u>
City share for collector street costs:	\$201,000.00	\$150,160.00
City share for non-assessable costs <sup>1</sup> :	\$230,750.00	\$239,265.00
City share for allowances and rounding adjustments:	<u>\$635.50</u>	<u>\$484.08</u>
Subtotal City share	\$432,385.50	\$389,909.08
City share for frontage <sup>2</sup>	<u>\$42,373.70</u>	<u>\$32,271.40</u>
TOTAL CITY SHARE	\$474,759.20 (54.3%)	\$422,180.48 (58.1%)
Assessments:	<u>\$400,240.80 (45.7%)</u>	<u>\$304,819.52 (41.9%)</u>
TOTAL PROJECT	\$875,000.00	\$727,000.00
<b>ASSESSMENT RATE</b>	<b>\$211.87/ft</b>	<b>\$161.36/ft</b>

<sup>1</sup> Costs for storm water related improvements

<sup>2</sup> Costs for storm water pond site and future Cecilee Street frontage

### ***Sidewalk Extension***

The total estimated cost of the sidewalk extension, including engineering and contingencies, is \$188,800. This total includes those costs for the additional width of the sidewalk on the east side of the street to provide a multi-use trail estimated to be \$55,525. The City's assessments policy does not specifically address the assessment for multi-use trails but does provide for the assessment of sidewalks. The policy also establishes the standard width of sidewalks at 5 feet unless otherwise approved or ordered by the Council. Although the policy is silent in regard to a City share for widths greater than 5 feet, it is proposed that the costs for the additional width of sidewalk (greater than the 4 foot width recommended for the west side) be considered a City share. This is proposed on the same basis that the additional costs associated with construction of a collector or arterial street are to be considered a City share when abutting residential properties. That is, the additional sidewalk width is proposed due to the character and use of the street rather than being necessary to serve residential needs. Typically shared use of residential street may satisfy the goals of the Complete Streets Policy with no more than 4 foot wide walks or, in many cases, with no walks. Recreational trails may or may not provide some of the same function as street corridor walks and trails, and therefore may or may not require different consideration in funding. As the Complete Streets Policy is further implemented, the assessment policy may need to clarify the assessment of surface improvements that appropriately address all forms of transportation. At this time the general intent of the provisions addressing the over sizing of streets abutting residential street is proposed to apply to the additional sidewalk width.

The following table provides a summary of the estimated costs, assessments, and City share for the proposed sidewalk extension.

City share for additional width:	\$55,525.00
City share for allowances, right-of-ways, and rounding adjustments:	<u>\$11,087.79</u>
Subtotal City share	\$66,612.79
City share for frontage <sup>2</sup>	<u>\$10,738.90</u>
TOTAL CITY SHARE	\$77,351.69 (41.0%)
Assessments:	<u>\$111,448.31</u> (59.0%)
TOTAL PROJECT	\$188,800.00
<b>ASSESSMENT RATE</b>	<b>\$53.69/ft</b>

<sup>1</sup> Costs for storm water pond site and North Worthington alley

***Combined Grand Avenue Improvements***

The following table provides a summary of the estimated costs, assessments, and City share for the proposed street and sidewalk extensions.

	<u>CONCRETE</u>	<u>BITUMINOUS</u>
City share for collector street & trail width costs:	\$256,525.00	\$205,685.00
City share for non-assessable costs <sup>1</sup> :	\$230,750.00	\$239,265.00
City Share for allowances, right-of-ways And rounding adjustments	<u>\$11,723.29</u>	<u>\$11,571.87</u>
Subtotal City share	\$498,998.29	\$456,521.87
City share for frontage <sup>2</sup>	<u>\$53,112.6</u>	<u>\$43,010.30</u>
TOTAL CITY SHARE	\$552,110.89 (51.9%)	\$499,532.17 (54.6%)
Assessments:	<u>\$511,689.11</u> (48.1%)	<u>\$416,267.83</u> (45.4%)
TOTAL PROJECT	\$1,063,800.00	\$915,800.00

<sup>1</sup> Costs for storm water related improvements

<sup>2</sup> Costs for storm water pond site and North Worthington alley

Initial financing of the project costs would be through issuance of a PIR general obligation bond(s) with possible use of 401 construction fund reserves until such a bond is issued. The bond debt is to be recovered by special assessments and by special tax levy for the City share of the project.

## **Conclusion**

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The proposed Grand Avenue Street and Sidewalk Extension will provide service access to the pending and future developments abutting the extension. Based on the findings of this Preliminary Engineering Report, the proposed improvements are considered necessary, feasible, and cost-effectively address the future needs of the Grand Avenue corridor. It is recommended that the City proceed by approving this preliminary engineering report, continue the process by holding a public hearing on the proposed improvements, and ordering final plans and specifications in accordance with MS 429.

## **Proposed Schedule**

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The proposed project schedule is described below. It should be noted that the City Council can halt the process at any time by simply electing to not take action or otherwise terminating the project.

The proposed project schedule is described below. It should be noted that the City Council can halt the process at any time by simply electing to not take action or otherwise terminating the project.

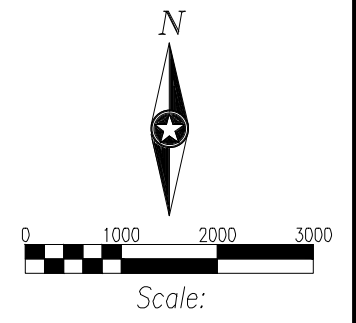
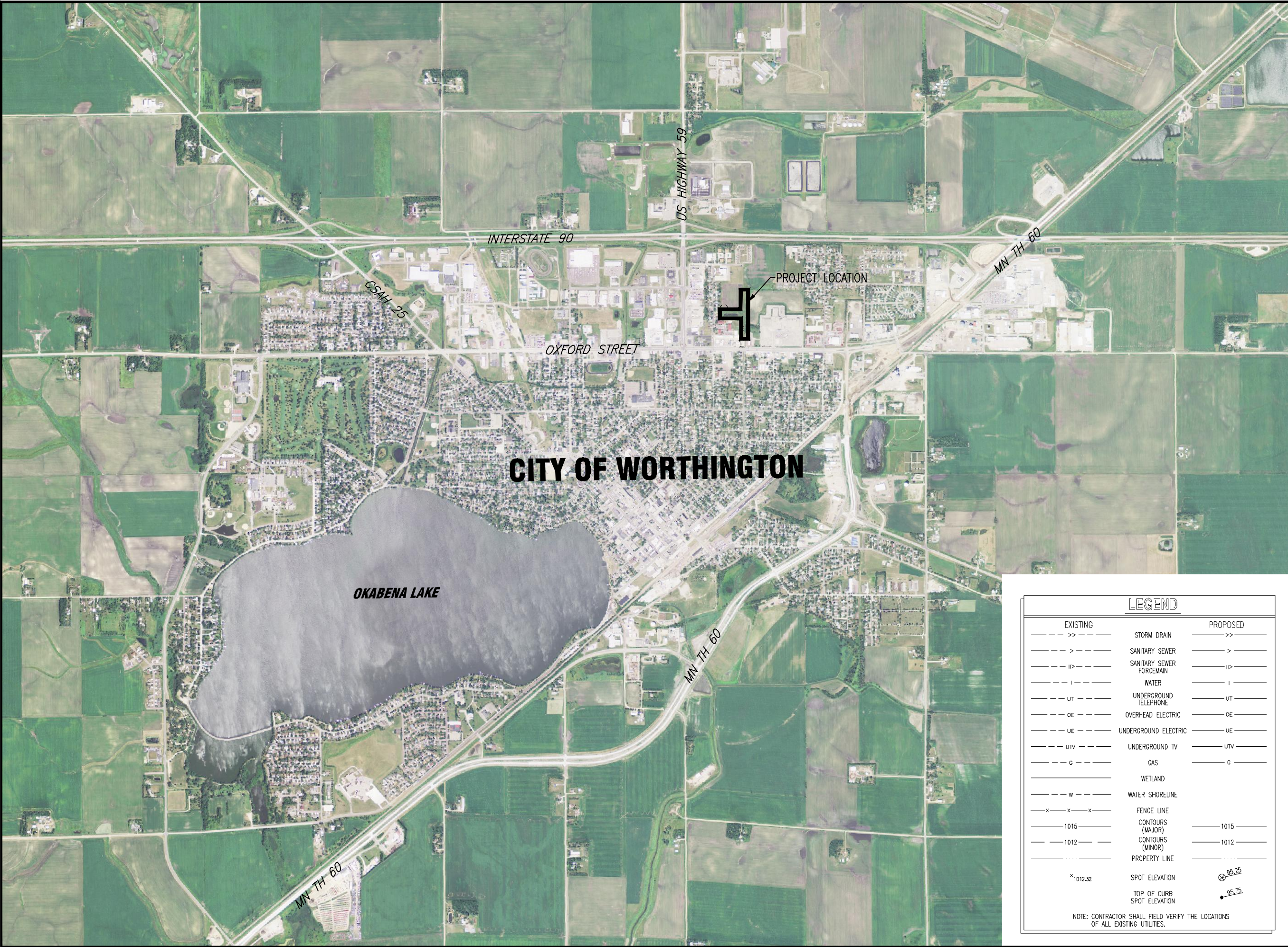
1. City Council passed a *Resolution Declaring Adequacy of Petition and Ordering Preparation of Report on Improvement (street extension)*, and a *Resolution Ordering Preparation of Report on Improvement (sidewalk extension)* **on April 27, 2015.**
2. City Council passes a *Resolution Receiving Report and Calling Hearing on Improvements* to indicate its plan to continue the process. **Estimated Date: June 8, 2015**
3. A public hearing on the proposed improvements is held. **Estimated date: June 22, 2015.**
4. If it is determined that the process will continue, the City Council may pass *Resolutions Ordering Improvement and Preparation of Plans*, which orders development of engineering plans and specifications necessary for soliciting bids for the project. **Estimated date: June 22, 2015.**
5. Plans and specifications for the proposed improvements are completed by ISG and submitted to The City of Worthington for review and approval. **Estimated date: June 29, 2015**
6. City Engineer's review of plans and specifications is completed. **Estimated date: July 3, 2015**
7. Final plans and specification revisions are completed by ISG. **Estimated date: July 8, 2015.**
8. After the City Council considers the presentation of the plans and specifications, it may pass a *Resolution Approving Plans and Specifications and Ordering an Advertisement for Bids*. **Estimated date: July 13, 2015.**
9. The advertisement for bids must be published in the official local newspaper and trade publication at least three weeks prior to the bid opening date. **Estimated date: July 17 - August 7, 2015.**
10. Submitted bids are received and publicly opened. **Estimated date: August 7, 2015.**
11. If the City Council wishes to continue with the improvements after the consideration of bids, the City Council may award the project to the lowest responsible bidder. **Estimated date: August 10, 2015.**
12. Construction begins. **Estimated date: August 24, 2015.**



13. Complete Storm Sewer and Subgrade prep. **Estimated date: September 8, 2015.**
14. Complete Aggregate Base. **Estimated date: Prior to September 18, 2015. (Road remains closed.)**
15. Pave first lift (bituminous). **Estimated date: September 23, 2015.**
  - i.* **Road Opens September 24, 2015**
  - b. Paving (concrete). **Estimated date: September 23, 2105.**
    - i.* **Road Opens October 7, 2015**
16. Pave concrete walks. **Estimated date: May 2, 2016.**
17. Final Grading & Seeding. **Estimated date: May 23, 2016.**
18. Final Punch list, seeding touch ups, sod, etc. **Estimated date: June 17, 2016.**

## **Appendix A: Exhibits**





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PROJECT

CITY OF  
WORTHINGTON

GRAND AVENUE  
EXTENSION

WORTHINGTONMINNESOTA

REVISION SCHEDULE		
NO	DATE	DESCRIPTION

PROJECT NO.	16841
FILE NAME	16841 PRELIMS
DRAWN BY	KDS
DESIGNED BY	CJB
REVIEWED BY	CJB
ISSUE DATE	
CLIENT PROJECT NO.	

TITLE

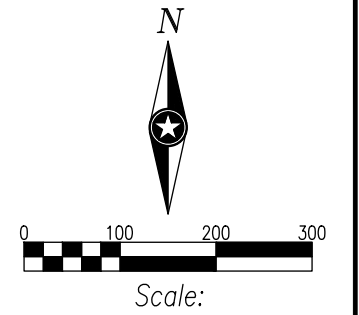
PROJECT  
LOCATION

SHEET

CONCEPT

LEGEND		
EXISTING		PROPOSED
---	STORM DRAIN	---
->-	SANITARY SEWER	->-
-II>-	SANITARY SEWER FORCEMAIN	-II>-
-I---	WATER	-I---
-UT---	UNDERGROUND TELEPHONE	-UT---
-OE---	OVERHEAD ELECTRIC	-OE---
-UE---	UNDERGROUND ELECTRIC	-UE---
-UTV---	UNDERGROUND TV	-UTV---
-G---	GAS	-G---
---	WETLAND	---
-W---	WATER SHORELINE	-W---
-X-X-X-	FENCE LINE	-X-X-X-
-1015-	CONTOURS (MAJOR)	-1015-
-1012-	CONTOURS (MINOR)	-1012-
-....-	PROPERTY LINE	-....-
X1012.32	SPOT ELEVATION	95.25
	TOP OF CURB	95.15
	SPOT ELEVATION	
NOTE: CONTRACTOR SHALL FIELD VERIFY THE LOCATIONS OF ALL EXISTING UTILITIES.		





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PROJECT

**CITY OF  
WORTHINGTON**

**GRAND AVENUE  
EXTENSION**

WORTHINGTONMINNESOTA

REVISION SCHEDULE		
NO	DATE	DESCRIPTION

PROJECT NO.	16841
FILE NAME	16841 PRELIMS
DRAWN BY	KDS
DESIGNED BY	CJB
REVIEWED BY	CJB
ISSUE DATE	
CLIENT PROJECT NO.	

TITLE

**EXISTING  
CONDITIONS**

SHEET

**CONCEPT**





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PROJECT

**CITY OF  
WORTHINGTON**

## GRAND AVENUE EXTENSION

WORTHINGTON MINNESOTA

[illegible]

PROJECT NO.	16841
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FILE NAME	16841 PRELIMS
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DRAWN BY	KDS
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DESIGNED BY	CJB
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REVIEWED BY	CJB
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ISSUE DATE

CLIENT PROJECT NO.

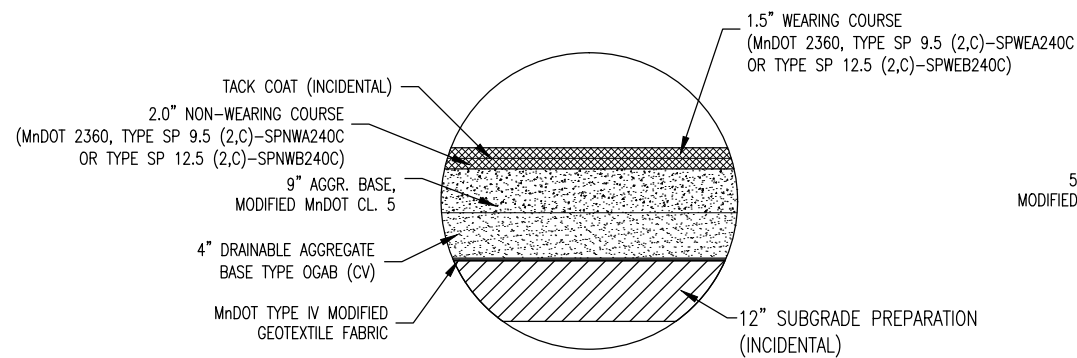
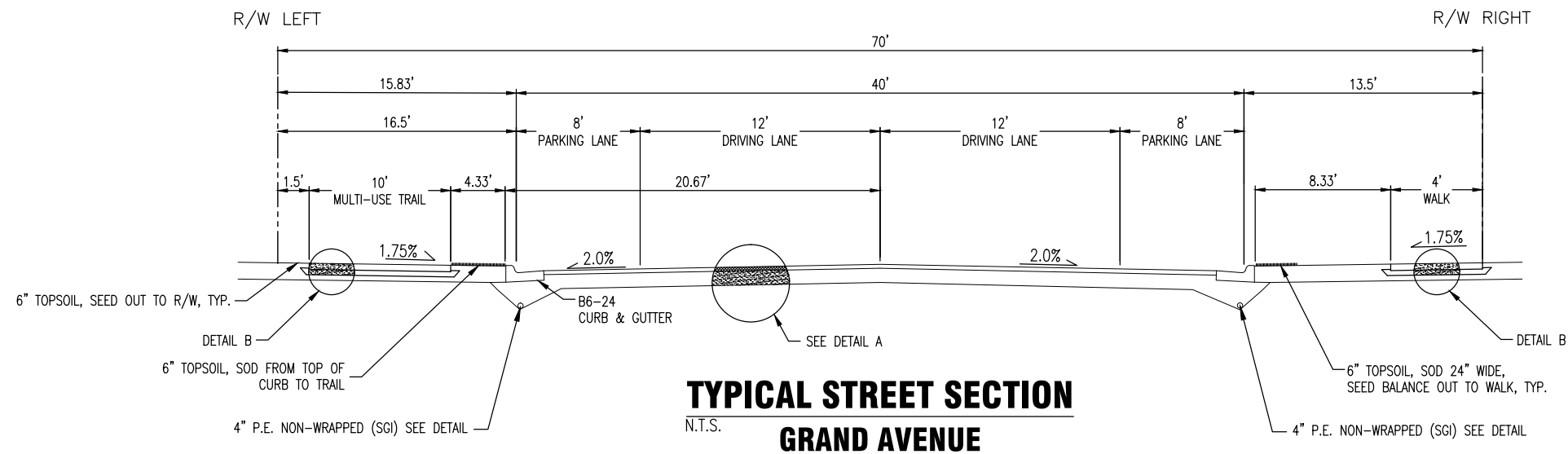
TITLE
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## PROPOSED CONDITIONS

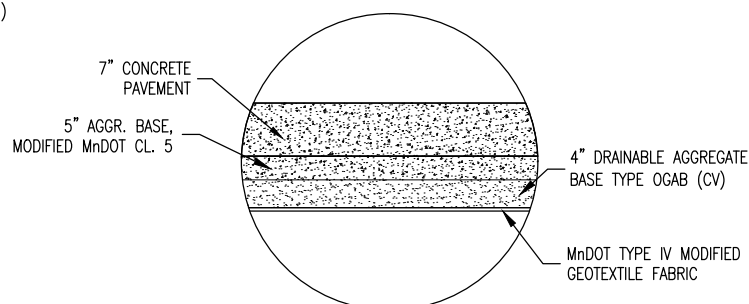
SHEET

## CONCEPT

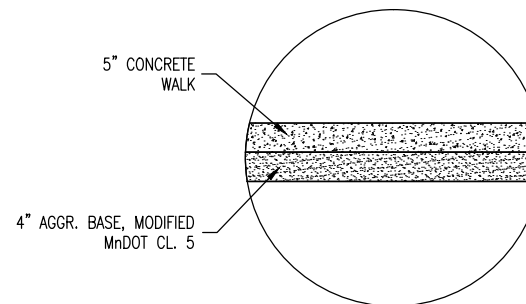




**DETAIL A (BID #1)**  
**BITUMINOUS ROADWAY**



**DETAIL A (BID #2)**  
**CONCRETE ROADWAY**



**DETAIL B (BID #3)**  
**CONCRETE SIDEWALK/MULTI-USE TRAIL**

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION, OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

CHARLES J. BRANDEL

DATE \_\_\_\_\_ LIC. NO. 43359

I HEREBY CERTIFY THAT THIS PLAN, SPECIFICATION, OR REPORT WAS PREPARED BY ME OR UNDER MY DIRECT SUPERVISION AND THAT I AM A DULY LICENSED PROFESSIONAL ENGINEER UNDER THE LAWS OF THE STATE OF MINNESOTA.

DATE \_\_\_\_\_ LIC. NO. \_\_\_\_\_

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PROJECT	
CITY OF WORTHINGTON	
GRAND AVENUE EXTENSION	
WORTHINGTON	MINNESOTA

REVISION SCHEDULE		
NO	DATE	DESCRIPTION

PROJECT NO.	16841
FILE NAME	16841 TYP SEC-DET
DRAWN BY	EJR/JAG/KDS
DESIGNED BY	KDS
REVIEWED BY	CJB/KDS
ISSUE DATE	—
CLIENT PROJECT NO.	-

TITLE
TYPICAL SECTION

## **Appendix B: Storm Water Report**

May 31, 2015



Mr. Dwayne Haffield, PE  
City Engineer  
City of Worthington  
303 9<sup>th</sup> Street, P.O. Box 279  
Worthington, MN 56187

RE: Grand Avenue Storm Water Report

Dear Mr. Haffield:

Enclosed is the report for the Storm Water Report for the City of Worthington Grand Avenue Street Extension. Short Elliott Hendrickson, Inc. (SEH) completed the Preliminary Storm Water Report as part of the 2009 Grand Avenue Sewer and Storm Water Extension Plan. The Minnesota Pollution Control Agency (MPCA) has since released new specifications regarding a water quality volume of 1-inch of runoff from the new impervious surfaces created by the project; increased from ½-inch. The National Oceanic and Atmospheric Association (NOAA) has also released new rainfall-frequency data, called Atlas 14. I+S Group (ISG) has completed a revised Storm Water Report for the 2014 Grand Avenue Street Extension.

The site mentioned above is located southeast of the intersection of Interstate 90 (I-90) and Highway 59. The SEH report addressed the routing and ponding requirements for rate control and volume in this area and the evaluation of the design capacities of the storm sewer system that has now been constructed. This report completed by ISG addresses the increased 10-year and 100-year rainfall numbers and the ½-inch increase in the MPCA water quality volume and the need to increase the size of the existing pond, based exclusively on these increases. The report completed by ISG used most of the information previously submitted by SEH to the City of Worthington regarding the Grand Avenue Storm Water Retention pond, however, did alter some of the drainage areas.

#### **MPCA and NOAA Standards**

The existing storm water detention pond was designed to meet the MPCA's National Pollutant Discharge Elimination System (NPDES) Construction Storm Water Permit. The site is partially located in the Heron Lake Watershed District and the Okabena-Ocheda Watershed District. The MPCA NPDES Permit has increased the water quality volume from ½-inch to 1-inch of runoff from the new impervious surfaces created by the project. The NPDES Permit design criteria for the dead-storage volume remained at 1,800 cubic feet per acre of contributing watershed, and water quality discharge of no more than 5.66 cfs per acre of surface area of the pond.

The Preliminary Storm Water Report compared the pre-pond conditions to the overall proposed conditions after all street, housing, and commercial development have taken place. The proposed end result will become approximately 66% of the existing watershed being converted to impervious area. Table 1 below shows the standards for both the MPCA and NOAA rainfall that are referenced throughout this report.

115 East Hickory Street, Suite 300 + Mankato, MN 56001

info@is-grp.com + [www.is-grp.com](http://www.is-grp.com)

P: 507.387.6651

**I+S GROUP**



**Table 1: MPCA & NOAA Standards**

	Dead Storage (1,800 cf/acre)	Runoff from new impervious area (in/acre of new impervious area)	Water Quality Discharge (cfs/acre)	10-year rainfall event (inches)	100-year rainfall event (inches)
Old Standards	1.26	0.5	5.66	4.20	6.00
New Standards	1.26	1.0	5.66	4.46	7.44

Table 2 below shows the pre-pond runoff rate versus the proposed runoff rate (after Grand Avenue and Cecilee Street have been constructed and development has been completed) for the original design based on the Preliminary Storm Water Report by SEH.

**Table 2: Original Design**

	Pre-Pond Construction Runoff Rate (CFS)	Proposed Runoff Rate (with Future Development) (CFS)
Original Design		
10-year rainfall event	25.0	11.4
100-year rainfall event	46.4	30.2

Based on the Preliminary Storm Water Report, the outlet for the pond was to be constructed with a 15-inch pipe leading to the 60-inch riser structure. From there, the riser structure would connect to the existing 36-inch RCP storm sewer system. However, based on the construction plans, an 18-inch pipe was installed instead of the 15-inch. Also, based on the construction plans, the elevations of each of the outlet devices was different than the model completed by SEH. Table 3 below shows the pre-pond runoff rate versus the proposed runoff rate for the constructed design based off of the construction plans and topographic information collected by ISG.

**Table 3: Constructed Design**

	Pre-Pond Construction Runoff Rate (CFS)	Proposed Runoff Rate (with Future Development) (CFS)
Constructed Design		
10-year rainfall event	25.0	15.4
100-year rainfall event	46.4	43.6

With the new standards, as previously discussed, the size of the pond will need to be increased to meet these standards. With the required dead storage needed not increasing, all of the pond expansion will take place above the maintained water level of 1573.6 elevation. Table 4 below shows the pre-pond runoff rate versus the proposed runoff rate for the proposed pond design. The expanded pond was designed to match the storm water runoff for the 100-year storm event compared to the already constructed design.

**Table 4: New Proposed Design**

	Pre-Pond Construction Runoff Rate (CFS)	Proposed Runoff Rate (with Future Development) (CFS)
Proposed Design		
10-year rainfall event	28.4	10.5
100-year rainfall event	59.8	43.0

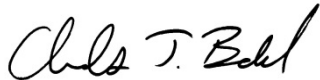
## Hydrology and Hydraulics

The HydroCAD, version 10.0, modeling software was used to recreate the Hydrologic and Hydraulic model created by SEH. The expanded detention pond was evaluated for the 10-year (4.46 inch) and 100-year (7.44-inch), NRCS 24-hours storm event. The inputs and results from the HydroCAD model are attached to this report. With the proposed pond expansion, the outlet will remain unchanged except for reducing the 18-inch pipe back to a 15-inch, as it was first designed in the Preliminary Storm Water Report. Limiting the outlet pipe to a 15-inch pipe will ensure that the peak flow leaving the pond does not exceed the previously constructed pond. All other existing storm sewer pipes and manholes will remain unchanged but will be extended to match the new alignment of the road.

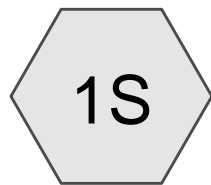
## Recommendations

The proposed expansion of the regional storm sewer pond assumes that all of Grand Avenue and Cecilee Street will be constructed and all future development be graded to drain to the existing and future proposed storm sewer. The expansion of the regional pond will eliminate the need for additional treatment for any future development in the area. However, water quality features such as rain gardens and/or small ponds are encouraged to further enhance the quality of water being drained to the local lakes, streams, and ditches.

Sincerely,



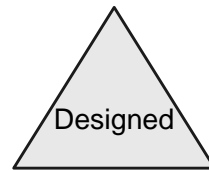
Chuck J. Brandel, PE  
Civil Engineer/Principal



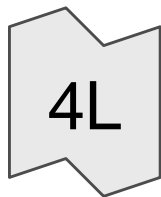
Before Pond  
Construction



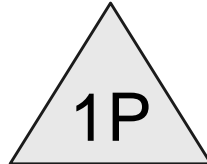
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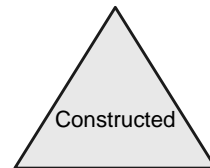
As Designed Pond



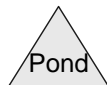
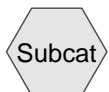
(new Link)



Expanded Pond



As Constructed Pond



**16841 Grand Avenue Storm***MN-Worthington 24-hr S1 10-yr 10-yr Rainfall=4.46"*

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**Summary for Subcatchment 1S: Before Pond Construction**

Runoff = 28.40 cfs @ 12.98 hrs, Volume= 5.064 af, Depth&gt; 1.98"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

MN-Worthington 24-hr S1 10-yr 10-yr Rainfall=4.46"

Area (ac)	CN	Description
30.700	75	Row crops, SR + CR, Good, HSG B
30.700		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.9	300	0.0033	0.20		<b>Sheet Flow,</b> Cultivated: Residue<=20% n= 0.060 P2= 2.80"
48.1	1,400	0.0029	0.48		<b>Shallow Concentrated Flow,</b> Cultivated Straight Rows Kv= 9.0 fps
73.0	1,700	Total			

**16841 Grand Avenue Storm***MN-Worthington 24-hr S1 100-yr 100-yr Rainfall=7.44"*

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**Summary for Subcatchment 1S: Before Pond Construction**

Runoff = 59.81 cfs @ 12.90 hrs, Volume= 11.394 af, Depth&gt; 4.45"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

MN-Worthington 24-hr S1 100-yr 100-yr Rainfall=7.44"

Area (ac)	CN	Description
30.700	75	Row crops, SR + CR, Good, HSG B
30.700		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
24.9	300	0.0033	0.20		<b>Sheet Flow,</b> Cultivated: Residue<=20% n= 0.060 P2= 2.80"
48.1	1,400	0.0029	0.48		<b>Shallow Concentrated Flow,</b> Cultivated Straight Rows Kv= 9.0 fps
73.0	1,700	Total			

**16841 Grand Avenue Storm***MN-Worthington 24-hr S1 10-yr 10-yr Rainfall=4.46"*

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**Summary for Subcatchment 2S: Proposed**

Runoff = 77.15 cfs @ 12.30 hrs, Volume= 7.310 af, Depth&gt; 2.86"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

MN-Worthington 24-hr S1 10-yr 10-yr Rainfall=4.46"

Area (ac)	CN	Description
2.800	88	Urban industrial, 72% imp, HSG B
3.900	72	1/3 acre lots, 30% imp, HSG B
16.700	85	1/8 acre lots, 65% imp, HSG B
7.300	92	Urban commercial, 85% imp, HSG B
30.700	85	Weighted Average
10.454		34.05% Pervious Area
20.246		65.95% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
25.0					<b>Direct Entry, Estimated</b>

**16841 Grand Avenue Storm***MN-Worthington 24-hr S1 100-yr 100-yr Rainfall=7.44"*

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**Summary for Subcatchment 2S: Proposed**

Runoff = 135.50 cfs @ 12.29 hrs, Volume= 14.439 af, Depth&gt; 5.64"

Runoff by SCS TR-20 method, UH=SCS, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

MN-Worthington 24-hr S1 100-yr 100-yr Rainfall=7.44"

Area (ac)	CN	Description
2.800	88	Urban industrial, 72% imp, HSG B
3.900	72	1/3 acre lots, 30% imp, HSG B
16.700	85	1/8 acre lots, 65% imp, HSG B
7.300	92	Urban commercial, 85% imp, HSG B
30.700	85	Weighted Average
10.454		34.05% Pervious Area
20.246		65.95% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
25.0					<b>Direct Entry, Estimated</b>

**16841 Grand Avenue Storm**

MN-Worthington 24-hr S1 10-yr 10-yr Rainfall=4.46"

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**Summary for Pond Designed: As Designed Pond**

Inflow Area = 30.700 ac, 65.95% Impervious, Inflow Depth > 2.86" for 10-yr event  
 Inflow = 77.15 cfs @ 12.30 hrs, Volume= 7.310 af  
 Outflow = 12.02 cfs @ 13.13 hrs, Volume= 7.062 af, Atten= 84%, Lag= 49.6 min  
 Primary = 12.02 cfs @ 13.13 hrs, Volume= 7.062 af  
 Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Starting Elev= 1,574.00' Surf.Area= 0.487 ac Storage= 1.322 af

Peak Elev= 1,578.14' @ 13.13 hrs Surf.Area= 1.032 ac Storage= 4.970 af (3.648 af above start)

Plug-Flow detention time= 265.4 min calculated for 5.738 af (78% of inflow)

Center-of-Mass det. time= 136.2 min ( 959.9 - 823.7 )

Volume	Invert	Avail.Storage	Storage Description
#1	1,570.00'	6.986 af	<b>Custom Stage Data (Prismatic)</b> Listed below (Recalc)
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,570.00	0.248	0.000	0.000
1,571.00	0.282	0.265	0.265
1,572.00	0.318	0.300	0.565
1,573.00	0.355	0.336	0.901
1,574.00	0.487	0.421	1.322
1,575.00	0.864	0.675	1.998
1,576.00	0.916	0.890	2.888
1,577.00	0.969	0.943	3.831
1,578.00	1.024	0.996	4.827
1,579.00	1.079	1.051	5.879
1,580.00	1.137	1.108	6.986

Device	Routing	Invert	Outlet Devices
#1	Primary	1,574.00'	<b>36.0" Round RCP_Round 36"</b> L= 30.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 1,574.00' / 1,573.58' S= 0.0140 '/ Cc= 0.900 n= 0.013, Flow Area= 7.07 sf
#2	Device 1	1,579.00'	<b>60.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#3	Device 1	1,571.75'	<b>15.0" Vert. Orifice/Grate</b> C= 0.600
#4	Secondary	1,580.00'	<b>20.0' long x 5.0' breadth Broad-Crested Rectangular Weir</b> Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88



## 16841 Grand Avenue Storm

MN-Worthington 24-hr S1 10-yr 10-yr Rainfall=4.46"

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**Primary OutFlow** Max=12.02 cfs @ 13.13 hrs HW=1,578.14' (Free Discharge)

↑ **1=RCP\_Round 36"** (Passes 12.02 cfs of 54.05 cfs potential flow)

↑ **2=Orifice/Grate** ( Controls 0.00 cfs)

↑ **3=Orifice/Grate** (Orifice Controls 12.02 cfs @ 9.80 fps)

**Secondary OutFlow** Max=0.00 cfs @ 0.00 hrs HW=1,574.00' (Free Discharge)

↑ **4=Broad-Crested Rectangular Weir** ( Controls 0.00 cfs)

**Summary for Pond Designed: As Designed Pond**

Inflow Area = 30.700 ac, 65.95% Impervious, Inflow Depth > 5.64" for 100-yr event  
 Inflow = 135.50 cfs @ 12.29 hrs, Volume= 14.439 af  
 Outflow = 63.04 cfs @ 12.68 hrs, Volume= 13.969 af, Atten= 53%, Lag= 23.8 min  
 Primary = 63.04 cfs @ 12.68 hrs, Volume= 13.969 af  
 Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Starting Elev= 1,574.00' Surf.Area= 0.487 ac Storage= 1.322 af

Peak Elev= 1,579.96' @ 12.68 hrs Surf.Area= 1.135 ac Storage= 6.945 af (5.622 af above start)

Plug-Flow detention time= 220.1 min calculated for 12.641 af (88% of inflow)

Center-of-Mass det. time= 128.6 min ( 938.6 - 810.0 )

Volume	Invert	Avail.Storage	Storage Description
#1	1,570.00'	6.986 af	<b>Custom Stage Data (Prismatic)</b> Listed below (Recalc)
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,570.00	0.248	0.000	0.000
1,571.00	0.282	0.265	0.265
1,572.00	0.318	0.300	0.565
1,573.00	0.355	0.336	0.901
1,574.00	0.487	0.421	1.322
1,575.00	0.864	0.675	1.998
1,576.00	0.916	0.890	2.888
1,577.00	0.969	0.943	3.831
1,578.00	1.024	0.996	4.827
1,579.00	1.079	1.051	5.879
1,580.00	1.137	1.108	6.986

Device	Routing	Invert	Outlet Devices
#1	Primary	1,574.00'	<b>36.0" Round RCP_Round 36"</b> L= 30.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 1,574.00' / 1,573.58' S= 0.0140 '/ Cc= 0.900 n= 0.013, Flow Area= 7.07 sf
#2	Device 1	1,579.00'	<b>60.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#3	Device 1	1,571.75'	<b>15.0" Vert. Orifice/Grate</b> C= 0.600
#4	Secondary	1,580.00'	<b>20.0' long x 5.0' breadth Broad-Crested Rectangular Weir</b> Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

## 16841 Grand Avenue Storm

MN-Worthington 24-hr S1 100-yr 100-yr Rainfall=7.44"

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**Primary OutFlow** Max=62.98 cfs @ 12.68 hrs HW=1,579.96' (Free Discharge)

↑ **1=RCP\_Round 36"** (Passes 62.98 cfs of 71.90 cfs potential flow)

↑ **2=Orifice/Grate** (Weir Controls 48.56 cfs @ 3.21 fps)

↑ **3=Orifice/Grate** (Orifice Controls 14.43 cfs @ 11.76 fps)

**Secondary OutFlow** Max=0.00 cfs @ 0.00 hrs HW=1,574.00' (Free Discharge)

↑ **4=Broad-Crested Rectangular Weir** ( Controls 0.00 cfs)

**16841 Grand Avenue Storm**

MN-Worthington 24-hr S1 10-yr 10-yr Rainfall=4.46"

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**Summary for Pond Constructed: As Constructed Pond**

Inflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af  
 Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min  
 Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af  
 Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs  
 Starting Elev= 1,574.00' Surf.Area= 0.487 ac Storage= 1.322 af  
 Peak Elev= 1,574.00' @ 0.00 hrs Surf.Area= 0.487 ac Storage= 1.322 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)  
 Center-of-Mass det. time= (not calculated: no inflow)

Volume	Invert	Avail.Storage	Storage Description
#1	1,570.00'	6.986 af	<b>Custom Stage Data (Prismatic)</b> Listed below (Recalc)

Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,570.00	0.248	0.000	0.000
1,571.00	0.282	0.265	0.265
1,572.00	0.318	0.300	0.565
1,573.00	0.355	0.336	0.901
1,574.00	0.487	0.421	1.322
1,575.00	0.864	0.675	1.998
1,576.00	0.916	0.890	2.888
1,577.00	0.969	0.943	3.831
1,578.00	1.024	0.996	4.827
1,579.00	1.079	1.051	5.879
1,580.00	1.137	1.108	6.986

Device	Routing	Invert	Outlet Devices
#1	Primary	1,574.00'	<b>36.0" Round RCP_Round 36"</b> L= 30.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 1,574.00' / 1,573.58' S= 0.0140 '/' Cc= 0.900 n= 0.013, Flow Area= 7.07 sf
#2	Device 1	1,578.00'	<b>60.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#3	Device 1	1,570.75'	<b>18.0" Vert. Orifice/Grate</b> C= 0.600
#4	Secondary	1,580.00'	<b>20.0' long x 5.0' breadth Broad-Crested Rectangular Weir</b> Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

**Primary OutFlow** Max=0.00 cfs @ 0.00 hrs HW=1,574.00' (Free Discharge)

↑ **1=RCP\_Round 36"** ( Controls 0.00 cfs)  
 ↑ **2=Orifice/Grate** ( Controls 0.00 cfs)  
 ↑ **3=Orifice/Grate** ( Controls 0.00 cfs)

**Secondary OutFlow** Max=0.00 cfs @ 0.00 hrs HW=1,574.00' (Free Discharge)

↑ **4=Broad-Crested Rectangular Weir** ( Controls 0.00 cfs)

**16841 Grand Avenue Storm**

MN-Worthington 24-hr S1 100-yr 100-yr Rainfall=7.44"

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**Summary for Pond Constructed: As Constructed Pond**

Inflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af  
 Outflow = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af, Atten= 0%, Lag= 0.0 min  
 Primary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af  
 Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs  
 Starting Elev= 1,574.00' Surf.Area= 0.487 ac Storage= 1.322 af  
 Peak Elev= 1,574.00' @ 0.00 hrs Surf.Area= 0.487 ac Storage= 1.322 af

Plug-Flow detention time= (not calculated: initial storage exceeds outflow)  
 Center-of-Mass det. time= (not calculated: no inflow)

Volume	Invert	Avail.Storage	Storage Description
#1	1,570.00'	6.986 af	<b>Custom Stage Data (Prismatic)</b> Listed below (Recalc)
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,570.00	0.248	0.000	0.000
1,571.00	0.282	0.265	0.265
1,572.00	0.318	0.300	0.565
1,573.00	0.355	0.336	0.901
1,574.00	0.487	0.421	1.322
1,575.00	0.864	0.675	1.998
1,576.00	0.916	0.890	2.888
1,577.00	0.969	0.943	3.831
1,578.00	1.024	0.996	4.827
1,579.00	1.079	1.051	5.879
1,580.00	1.137	1.108	6.986

Device	Routing	Invert	Outlet Devices
#1	Primary	1,574.00'	<b>36.0" Round RCP_Round 36"</b> L= 30.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 1,574.00' / 1,573.58' S= 0.0140 '/' Cc= 0.900 n= 0.013, Flow Area= 7.07 sf
#2	Device 1	1,578.00'	<b>60.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#3	Device 1	1,570.75'	<b>18.0" Vert. Orifice/Grate</b> C= 0.600
#4	Secondary	1,580.00'	<b>20.0' long x 5.0' breadth Broad-Crested Rectangular Weir</b> Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

**Primary OutFlow** Max=0.00 cfs @ 0.00 hrs HW=1,574.00' (Free Discharge)

↑ **1=RCP\_Round 36"** ( Controls 0.00 cfs)  
 ↑ **2=Orifice/Grate** ( Controls 0.00 cfs)  
 ↑ **3=Orifice/Grate** ( Controls 0.00 cfs)

**Secondary OutFlow** Max=0.00 cfs @ 0.00 hrs HW=1,574.00' (Free Discharge)

↑ **4=Broad-Crested Rectangular Weir** ( Controls 0.00 cfs)

**16841 Grand Avenue Storm**

MN-Worthington 24-hr S1 10-yr 10-yr Rainfall=4.46"

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**Summary for Pond 1P: Proposed Expanded Pond**

Inflow Area = 30.700 ac, 65.95% Impervious, Inflow Depth > 2.86" for 10-yr event  
 Inflow = 77.15 cfs @ 12.30 hrs, Volume= 7.310 af  
 Outflow = 10.35 cfs @ 13.22 hrs, Volume= 6.686 af, Atten= 87%, Lag= 55.0 min  
 Primary = 10.35 cfs @ 13.22 hrs, Volume= 6.686 af  
 Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Starting Elev= 1,573.75' Surf.Area= 0.785 ac Storage= 1.363 af

Peak Elev= 1,576.82' @ 13.22 hrs Surf.Area= 1.526 ac Storage= 5.339 af (3.976 af above start)

Plug-Flow detention time= 311.7 min calculated for 5.321 af (73% of inflow)

Center-of-Mass det. time= 167.0 min ( 990.7 - 823.7 )

Volume	Invert	Avail.Storage	Storage Description
#1	1,570.00'	11.106 af	<b>Custom Stage Data (Prismatic)</b> Listed below (Recalc)
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,570.00	0.243	0.000	0.000
1,571.00	0.289	0.266	0.266
1,572.00	0.337	0.313	0.579
1,572.60	0.366	0.211	0.790
1,573.60	0.576	0.471	1.261
1,574.00	1.132	0.342	1.603
1,575.00	1.267	1.199	2.802
1,576.00	1.408	1.337	4.140
1,577.00	1.552	1.480	5.620
1,578.00	1.703	1.627	7.247
1,579.00	1.928	1.815	9.063
1,580.00	2.158	2.043	11.106

Device	Routing	Invert	Outlet Devices
#1	Primary	1,573.75'	<b>36.0" Round RCP_Round 36"</b> L= 30.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 1,573.75' / 1,573.58' S= 0.0057 '/' Cc= 0.900 n= 0.013, Flow Area= 7.07 sf
#2	Device 1	1,578.00'	<b>60.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#3	Device 1	1,570.75'	<b>15.0" Vert. Orifice/Grate</b> C= 0.600
#4	Secondary	1,580.00'	<b>20.0' long x 5.0' breadth Broad-Crested Rectangular Weir</b> Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88

## 16841 Grand Avenue Storm

MN-Worthington 24-hr S1 10-yr 10-yr Rainfall=4.46"

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**Primary OutFlow** Max=10.35 cfs @ 13.22 hrs HW=1,576.82' (Free Discharge)

↑ **1=RCP\_Round 36"** (Passes 10.35 cfs of 34.98 cfs potential flow)

↑ **2=Orifice/Grate** ( Controls 0.00 cfs)

↑ **3=Orifice/Grate** (Orifice Controls 10.35 cfs @ 8.43 fps)

**Secondary OutFlow** Max=0.00 cfs @ 0.00 hrs HW=1,573.75' (Free Discharge)

↑ **4=Broad-Crested Rectangular Weir** ( Controls 0.00 cfs)

### Summary for Pond 1P: Proposed Expanded Pond

Inflow Area = 30.700 ac, 65.95% Impervious, Inflow Depth > 5.64" for 100-yr event  
 Inflow = 135.50 cfs @ 12.29 hrs, Volume= 14.439 af  
 Outflow = 38.07 cfs @ 12.87 hrs, Volume= 12.928 af, Atten= 72%, Lag= 35.3 min  
 Primary = 38.07 cfs @ 12.87 hrs, Volume= 12.928 af  
 Secondary = 0.00 cfs @ 0.00 hrs, Volume= 0.000 af

Routing by Stor-Ind method, Time Span= 0.00-24.00 hrs, dt= 0.01 hrs

Starting Elev= 1,573.75' Surf.Area= 0.785 ac Storage= 1.363 af

Peak Elev= 1,578.62' @ 12.87 hrs Surf.Area= 1.842 ac Storage= 8.344 af (6.981 af above start)

Plug-Flow detention time= 287.9 min calculated for 11.560 af (80% of inflow)

Center-of-Mass det. time= 172.8 min ( 982.8 - 810.0 )

Volume	Invert	Avail.Storage	Storage Description
#1	1,570.00'	11.106 af	<b>Custom Stage Data (Prismatic)</b> Listed below (Recalc)
Elevation (feet)	Surf.Area (acres)	Inc.Store (acre-feet)	Cum.Store (acre-feet)
1,570.00	0.243	0.000	0.000
1,571.00	0.289	0.266	0.266
1,572.00	0.337	0.313	0.579
1,572.60	0.366	0.211	0.790
1,573.60	0.576	0.471	1.261
1,574.00	1.132	0.342	1.603
1,575.00	1.267	1.199	2.802
1,576.00	1.408	1.337	4.140
1,577.00	1.552	1.480	5.620
1,578.00	1.703	1.627	7.247
1,579.00	1.928	1.815	9.063
1,580.00	2.158	2.043	11.106

Device	Routing	Invert	Outlet Devices
#1	Primary	1,573.75'	<b>36.0" Round RCP_Round 36"</b> L= 30.0' RCP, square edge headwall, Ke= 0.500 Inlet / Outlet Invert= 1,573.75' / 1,573.58' S= 0.0057 '/' Cc= 0.900 n= 0.013, Flow Area= 7.07 sf
#2	Device 1	1,578.00'	<b>60.0" Horiz. Orifice/Grate</b> C= 0.600 Limited to weir flow at low heads
#3	Device 1	1,570.75'	<b>15.0" Vert. Orifice/Grate</b> C= 0.600
#4	Secondary	1,580.00'	<b>20.0' long x 5.0' breadth Broad-Crested Rectangular Weir</b> Head (feet) 0.20 0.40 0.60 0.80 1.00 1.20 1.40 1.60 1.80 2.00 2.50 3.00 3.50 4.00 4.50 5.00 5.50 Coef. (English) 2.34 2.50 2.70 2.68 2.68 2.66 2.65 2.65 2.65 2.65 2.67 2.66 2.68 2.70 2.74 2.79 2.88



## 16841 Grand Avenue Storm

MN-Worthington 24-hr S1 100-yr 100-yr Rainfall=7.44"

Prepared by {enter your company name here}

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**Primary OutFlow** Max=38.03 cfs @ 12.87 hrs HW=1,578.62' (Free Discharge)

↑ **1=RCP\_Round 36"** (Passes 38.03 cfs of 61.80 cfs potential flow)

↑ **2=Orifice/Grate** (Weir Controls 25.00 cfs @ 2.57 fps)

↑ **3=Orifice/Grate** (Orifice Controls 13.04 cfs @ 10.62 fps)

**Secondary OutFlow** Max=0.00 cfs @ 0.00 hrs HW=1,573.75' (Free Discharge)

↑ **4=Broad-Crested Rectangular Weir** ( Controls 0.00 cfs)