AECOM

Prepared for:
City of Mequon
Mequon, WI

Prepared by:
AECOM
1555 N RiverCenter Drive, Suite 214
60288274
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City of Mequon East Trunk Sewer and EGA System Improvements

Preliminary Engineering Report

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1.0 Introduction

The City of Mequon's (City) East Trunk Sewer (ETS) system has experienced surcharged conditions and the need to bypass pump at several locations. Bypass pumping was required to minimize basement flooding during significant wet-weather events which exceed the capacity of the existing sanitary system. The Sewer Utility responded by commissioning a Sanitary Sewer System Evaluation (SSSE) in 2010-2011 which identified required improvements in the City's sanitary sewer system, including the East Trunk Sewer (ETS). The report identifies the ETS as the largest of the four sewersheds in the City, encompassing a total modeled area of 6,600 acres and 10 public lift stations and selected the area downstream of Lift Station E as the focus for this phase of the preliminary engineering work.

2.0 Background

The City of Mequon's SSSE report finalized in January 2011 provided information on dry and wet weather flows under existing and future development conditions. The report also developed alternatives that could enhance system performance including upgrading key lift stations, adding additional sewer capacity through increased conveyance and/or storage, and reducing inflow and infiltration. The City is held to specific flow limitations at various connection points to the Milwaukee Metropolitan Sewerage District (District) system and to flow increases based on requested development agreed to by the City and the District per the 2020 Facilities Planning effort of the District.

As an extension of that study, the City engaged AECOM in association with GAI Consultants, Inc. on February 25, 2013 to perform Phase I Preliminary Engineering services for the ETS and the East Growth Area (EGA). The preliminary engineering consisted of reviewing the January 2011 SSSE Report and other pertinent documentation, including reviewing and confirming the previous modeling effort. The scope also included coordinating expanded flow monitoring of the lower portion of the ETS and updating the calibrated hydraulic model to more closely correspond to the conditions observed by the City in this area of the system.

This report reviews and evaluates recommended Alternative 4 from the SSSE Report against additional alternatives developed during this preliminary engineering study to achieve the goals set forth therein. Details of these efforts are presented below.

2.1 Preliminary Engineering

Wet-weather history – The lower portion of the ETS has experienced an increase in the frequency of Sanitary Sewer Overflow (SSO) events in the past five years. Table 1 – Bypass History includes a brief summary of recent past SSOs with dates, rainfall magnitude, number of bypass locations and total volume of sewage bypassed.

Table 1 – Bypass History

Year	Date	Size of Rainfall (In)	No. of Bypass Locations	Total Volume Bypassed (Gallons)
2015	April 9	4.2	12	2,612,400
2014	April 1	FM Break	1	3,155
	April 14	2.1	1	72,000
	June 18	4.0	8	1,268,910
2013	April 10	4.23	1	30,600
	April 18	1.3	1	54,600
	June 13	FM Break	1	1,200
	Nov. 8	FM Break	1	150
2012	May 11	FM Break	1	volume not reported
2011	April 26	2.04	3	166,000
	June 20	FM Break	1	3,000
2010	July 15	3.45	4	489,325
	July 22	3.5	2	9,875

Hydraulic Modeling - In 2013 the City raised concerns about how the sanitary sewer system performs based on field observations compared to the existing sanitary sewer model representation of the system developed in the SSE study. The two concerns raised by the City were: 1) the model was overestimating flows and hydraulic grade line upstream of the bypass location (Brookdale Drive and Clover Lane) and; 2) the model was underestimating the impact of the force main that enters the system at Zedler Lane and Port Washington Road which they observed to be causing backwater effects and an elevated hydraulic grade line that was not matching the model results.

There was only one flow meter in the field during the original study that was used to calibrate this area, which was based upon a 2009 rainfall event. The lack of information available to calibrate the model led to the decision to install 8 flow meters in an area of the East Trunk Sanitary Sewer system from Hidden Reserve Court south of Hidden Reserve Circle south to West Zedler Lane extended east of North Port Washington Road to better determine the existing system response to rainfall events. AECOM conducted a detailed review of the data from these meters and summarized the results in the *ETS Model Modification Memo* (Source: AECOM, April 24, 2015), located in Appendix A.

A review of the meter results from 2014 and the subsequent recommendation to make sanitary sewer model adjustments based on that data was documented in the *2014 East Trunk Sanitary Sewer Flow Monitoring Analysis Tech Memo* (Source: AECOM, March 13, 2015), located in Appendix B.

Following that memorandum development, AECOM requested additional rainfall and flow meter data from the District and data from the City of Mequon. Flow monitoring data from the June 17-18,

2014 rain event was utilized to make adjustments to the calibrated model to more accurately match the modeled system response to the metered rain event.

Updated rainfall information was entered into the model with the focus on system performance during June 17-18, 2014. The flow meter data was then used as a guide to adjust the various flow generation components in the model for the area of interest to refine the system and better align with 2014 observed data.

Based on the greater flows of the 2014 event and modifying the model parameters to match simulated to measured peak flows and maximum hydraulic grade lines, the modified hydraulic model provided a reasonable representation of how the system operated during that event.

Following the model calibrations, the original 2009 rainfall was run. The simulated peak flows compared favorably with what the City expected to see and verified the integrity of the model modifications.

Compliance with District Maximum Release Rate – During the development of this Preliminary Engineering study, the District informed the City of Mequon on March 11, 2013 that under full-buildout conditions, the 5-year wet-weather peak hourly flow release rate at MS0409 at West Ravine Baye Road in Bayside is 29.8 cfs (19.3 mgd). This is higher than the value provided by the SSSE effort. The modified hydraulic model results in a release rate of 26.8 cfs (17.3 mgd), allowing approximately a 10% buffer.

Development of Alternatives – Using the SSSE study as a basis for further analysis, Alternatives 4 and 5 received favorable rankings for achieving the goals identified in the report. Although both alternatives included increasing capacity of the ETS by upsizing or running parallel sewer lines southeast of Oriole Lane and Sunnydale Lane through Hidden Reserve subdivision, the chief difference is that Alternative 4 utilizes in-line storage. The City has clearly indicated in their RFP that an off-line storage recommendation would be a solution that they will consider only after all other alternatives have been dismissed. As Alternative 5 utilizes off-line storage, Alternative 4 has become the de-facto recommended alternative of the SSSE report.

AECOM reviewed Alternative 4 and analyzed its performance based on the latest storm data available from the June 17-18, 2014 event. Other similar configurations and sewer routes were developed in a series of seven potential alternatives to address the system deficiencies, ranging from temporary bypass pumping to a “deep tunnel” relief sewer. In general, the seven alternatives provided increasing levels of protection with corresponding cost increases.

AECOM met with the City on July 10, 2015 and presented all seven alternatives with their associated benefits, drawbacks and estimated construction costs. Details of each alternative can be referenced in the *Alternative Evaluation Technical Memorandum* (AECOM, September 17, 2015), located in Appendix C.

In addition to addressing the primary deficiencies of the ETS, the City had some further considerations that they desired to be included in the selected alternative, as discussed below:

Increased Conveyance Capacity – Alternative 3 from the Technical Memorandum proposed a 12-inch gravity relief sewer to divert flow around the Hidden Reserve subdivision where a significant concentration of properties experience basement backups during severe wet-weather events. Since it appeared that there may not be sufficient room to construct a parallel sewer line through the

subdivision, the proposed relief sewer was located in N. Port Washington Road from Winding Hollow Lane to Donges Bay Road.

However, the proposed route of the 12-inch gravity sewer would require cutting an extensive section of new pavement in Port Washington Road. Therefore, the project team agreed that the existing sewer through the subdivision would be replaced with a larger diameter sewer ranging from 24-inches to 27-inches in the same location to relieve localized surcharging.

East Growth Area (EGA) – The City is committed to providing capacity in the system to serve the EGA along N. Port Washington Road between Highland Road and Pioneer Road, west of I-43, where the City is aware of development interests. The consensus of the project team was to drain the EGA by gravity sewer as far south along Port Washington Road as feasible, which appears to be in the area of Dorothy Place. A lift station and potentially an underground storage facility to reduce peak flows would be constructed there to collect the sanitary sewerage from the future EGA development and pump it through a force main to the 48” storage/relief sewer in Port Washington Road. It appears that the smaller diameter force main could be directionally drilled along Port Washington Road to minimize disruption of the road and surrounding area.

Lift Station E Relief – In an effort to moderate the pumping demands on the aging infrastructure of Lift Station E and reduce future bypassing needs at this location, the project team agreed to abandon the existing Lift Station F force main and construct a relocated force main to a proposed wet well/lift station receiving flow from the EGA near Dorothy Place and N. Port Washington Road. The force main from the EGA lift station would convey flow through a long force main to the 48-inch relief sewer at Donges Bay Road.

2.2 Alternative 6a

After discussing in detail each alternative with the City, Alternatives 1, 2, 4, 5 and 7 were eliminated for reasons discussed in the *Alternative Evaluation Technical Memorandum*. The consensus of the project team was to move forward with a "hybrid" alternative incorporating elements from Alternatives 3 and 6 as well as the additional components discussed above to provide an increased level of protection to Lift Station E. This new Alternative 6a is discussed in detail in *Alternative 6a Technical Memorandum* (AECOM, September 17, 2015), located in Appendix D. This memorandum was developed for the purpose of presenting the recommended alternative to the City of Mequon Sanitary Utility District Commission. On September 22, 2015, the Sanitary Utility District Commission unanimously approved the authorization for Staff to pursue preferred Alternative 6a. Components of Alternative 6a are included in Figure 1 – Alternative 6a below.

Legend

- EGA Lift Station
- Manhole where flow from EGA is pumped
- New Force Main
- Gravity Sewer Improvements
- LSF Force Main Diversion
- Lift Stations
- Manholes
- Gravity Main
- Force Main
- Abandoned
- East Growth Area

T
C
W
ST. MARY'S
CONCORDIA UNIVERSITY
East Growth Area Capacity
Lift Station E Relief
F
43
E
Lift Station E
167
MEQUON RD
57
Increased Conveyance Capacity of Hidden Reserve Sanitary Sewer
P
48-Inch Relief Sewer
Brookdale & Clover Bypass
48"
ZEDLER LN
48"
Connection to 48-Inch MIS
Q
PS

7/30/2015 R:\LKG\Mapping\Mequon\Projects\R13_0564_100_Sanitary\GIS\Alt_6a.mxd

City of Mequon
Ozaukee County, Wisconsin

Figure 1
Alternative 6a

N

0 2,500 ft

gai consultants
AECOM

Figure 1 includes proposed locations for the EGA gravity sewer and lift station, rerouted Lift Station F force main, 24-27 inch ETS gravity sewer replacement through Hidden Reserve subdivision and the initial location of the 48-inch diameter relief sewer. Although the relief sewer is shown on Zedler Lane and along the Union Pacific Railroad Company's railroad tracks, this portion of the alignment had not yet been finalized. Due to a myriad of varying conditions from the intersection of North Port Washington Road and Zedler Lane to the connection with District's interceptor sewer east of the railroad tracks just south of the Ozaukee County line, Alternative 6a was further refined with five potential sewer routes, indicated in Figure 3 - East Trunk Relief Sewer Alternative Routes. These routes are discussed in a later section of this report to establish a final recommended alternative.

Sanitary Utility District Commission Meeting – The City of Mequon presented the preferred Alternative 6a to their Sanitary Utility District Commission on September 22, 2015 for action. Based on the presentation and subsequent discussion, the Commission unanimously approved Alternative 6a to advance the project to Final Design.

2.3 Route Analysis

Geotechnical Investigation - Based on AECOM's review of the Soil Surveys of Ozaukee and Milwaukee Counties, the near surface soils (upper 5 to 6 feet) along the alignment are mapped as those belonging to the Kewaunee and Manawa silt loam units. There is a portion of the alignment north of Donges Bay Road that extends through areas mapped as the Poygan silty clay loam and the Muskego muck. The majority of these soils consist of fine grained silts and clays, with trace to little amounts of sand and gravel. The Muskego muck consists of shallow moderately to highly organic deposits (peat). Soils at greater depths likely consist of clayey glacial till deposits of the Ozaukee Formation. Shallow groundwater is also likely present. These soils should be conducive to installation of utilities using standard cut and cover techniques.

Excavation retention may be needed where the alignment is adjacent to settlement sensitive critical infrastructure. Groundwater inflows are expected to be low to moderate and can most likely be managed using typical sump pit and pump techniques. For deeper installations extending into the Ozaukee till formation, occasional cobbles and boulders may be encountered.

A subsequent preliminary additional soil delineation review has determined that the veins of outwash plains which are the most likely of the Ozaukee Formation sub-members to include sand, gravel, cobbles and boulders, lie primarily along the Milwaukee River watershed. Since the Milwaukee River is located to the west and outside of the recommended alternative alignment zone of the East Trunk relief sewer, potential tunneling should carry a reduced risk of encountering cobbles and boulders which tend to be inherently challenging to the tunnel operations.

A cursory review of bedrock elevations has also indicated that bedrock within the recommended alternative alignment zone of the East Trunk relief sewer lies between 50 feet and 200 feet below the ground surface. It is recommended that a detailed geotechnical investigation be performed during final design to confirm the expected conditions.

Flood Plains/Wetlands/Waterways - AECOM accessed the National Wetlands Inventory, the U.S. Fish and Wildlife Service, the Wisconsin Department of Natural Resources and Mequon files for the ETS and EGA sewer alignments to determine potential flood plain, wetland and waterway impacts to construction along each included alternative route. The information is presented graphically in Figure 3 - East Trunk Relief Sewer Alternative Routes introduced in Section 2.5.

Paired-Comparison Analysis to Establish Optimum Alternative – As discussed above, Alternative 6a was designed with five potential 48-inch diameter relief sewer routes from the intersection of North Port Washington Road and Zedler Lane to the connection with the District's interceptor sewer east of the railroad tracks just south of the Ozaukee County line. These alternative routes and their associated vertical alignments are also presented in Figures 3 and 4 respectively of Section 2.5 East Trunk Relief Sewer Alternative Routes.

2.4 Related Issues

Two other issues related to system performance included in the contract were to review the effects of flow diversions from the ETS to the Central Trunk Sewer (CTS) in Cedarburg Road and conduct an infiltration & inflow analysis. Each of these items is discussed in the following paragraphs.

Diversion to the Central Trunk Sewer – AECOM reviewed the effects of diverting flow from the short Lift Station E force main at East Sunnydale Lane and the long Lift Station E force main at Zedler Lane to the 36-inch CTS on Cedarburg Road for hydraulic relief. Current hydraulic conditions indicate that there is excess capacity in the Central Trunk Sewer line that could be utilized for relief in the ETS line, with District approval. Conveyance lines for the diversions would range from approximately 2.15 to 2.6 miles in length over an elevation change of 81 feet. This change in elevation would result in an extremely deep gravity sewer or require another force main. After discussions with the City, it was determined that anticipated growth and development in the Central area of Mequon would result in additional flow that would compete for the excess capacity so the diversion was not considered a viable long term solution. Similarly, diversions from Lift Station G and Lift Station T were not considered any further.

Infiltration & Inflow (I/I) – AECOM researched I/I in and around the metropolitan Milwaukee area to determine industry accepted reduction rates that may be applied to evaluation areas for the ETS. A pilot study conducted in Wauwatosa demonstrated that the majority of I/I occurs in the private sewer laterals and flow reductions near 75% can be achieved by CIPP lining. However, these reductions were demonstrated under strict controls in individual laterals. System-wide data including main line, manhole, foundation drain, roof downspouts and other contributions are not available. Much of the available literature does not specifically include industry accepted percentage flow reductions. The District has placed limitations on acceptable I/I and regulated capacity for Satellite Municipalities like Mequon as documented in their 2020 Facilities Plan.

Based on an analysis of wet-weather and dry-weather flow monitoring, AECOM provided the City with the color coded map in Figure 2 Inflow/Infiltration Reduction Alternative illustrating I/I peaking factors in various sub-basins of the City and preliminary costs to perform lateral CIPP lining in selected areas. The City indicated that based on this information, they have prioritized their efforts and are continuing with strategic I/I reduction activities on both the private and public side to improve the current and future system performance.

Legend

- East Growth Area
- Lift Stations
- Manholes
- Gravity Main
- Force Main
- Abandoned
- Clay Sanitary Pipes

- TOTAL QUANTITY OF CLAY PIPE IN GREEN, BLUE, AND ORANGE AREA IS APPROXIMATELY 255,473 LF WITH 5110 LATERALS
- TOTAL INFLOW/INFILTRATION REMOVED DUE TO LINING LATERALS IS ESTIMATED AT 1 TO 2 CFS
- TOTAL COST TO LINING LATERALS IN GREEN, BLUE, AND ORANGE AREAS IS $38,321,000

T

C

W

ST. MARY'S

PEAKING FACTOR - 6.40
AREA EVALUATED AS PART OF THE PPII PROGRAM

G

F

T

43

H

PEAKING FACTOR - 9.62
REQUESTING 2 FLOW METERS WITHIN THIS BASIN TO ISOLATE I/I

E

PEAKING FACTOR - 6.80

167

57

CLAY PIPE NOT WITHIN STUDY AREA AND DOES NOT AFFECT LIFT STATION E

P

I

PEAKING FACTOR - 6.21

PEAKING FACTOR - 5.22

J

K

L

Q

PEAKING FACTOR - 2.41

5/13/2013 R:\LKG\Mapping\Mequon\Projects\R13_0564_100_Sanitary\GIS\Peaking.mxd

City of Mequon
Ozaukee County, Wisconsin

Figure 2
Inflow/Infiltration Reduction Alternative

N

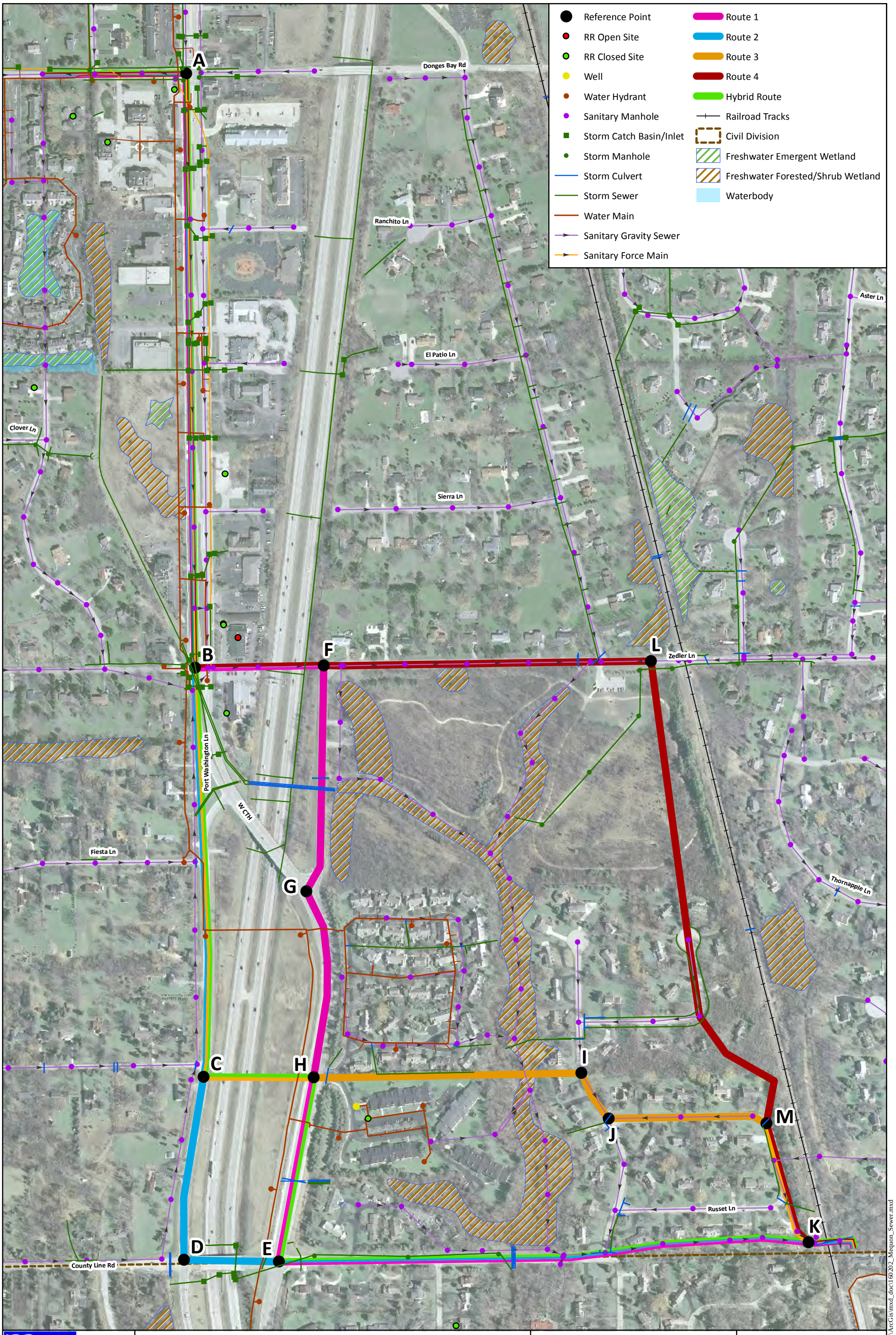
CRISPELL-SNYDER, INC.
PROFESSIONAL CONSULTANTS | A GAI COMPANY

1 inch equals 2,500 feet

2.5 East Trunk Relief Sewer Alternative Routes

The five alternative routes presented in Figure 3 East Trunk Relief Sewer Alternative Routes all have common components upstream of the intersection of North Port Washington Road and Zedler Lane, which will not change the results of the alternative evaluation. Therefore, only those portions downstream of the intersection were evaluated and ranked, including their respective costs, traffic, utilities, capacities, lengths, depths, and other factors.

The City required that the PE Study include evaluating impacts to traffic, access, public and worker safety, ease of maintenance and condition assessment to enhance the recommended final alternative. These criteria along with other suggested measures have been incorporated into the analysis to determine the optimum alternative. The method of evaluation used is referred to as the paired-comparison analysis, which will allow a non-biased means of alternative selection.



City of Mequon, WI

March, 2016 60288274

Figure 3
East Trunk Relief Sewer Alternative Routes

0 250 500 Feet

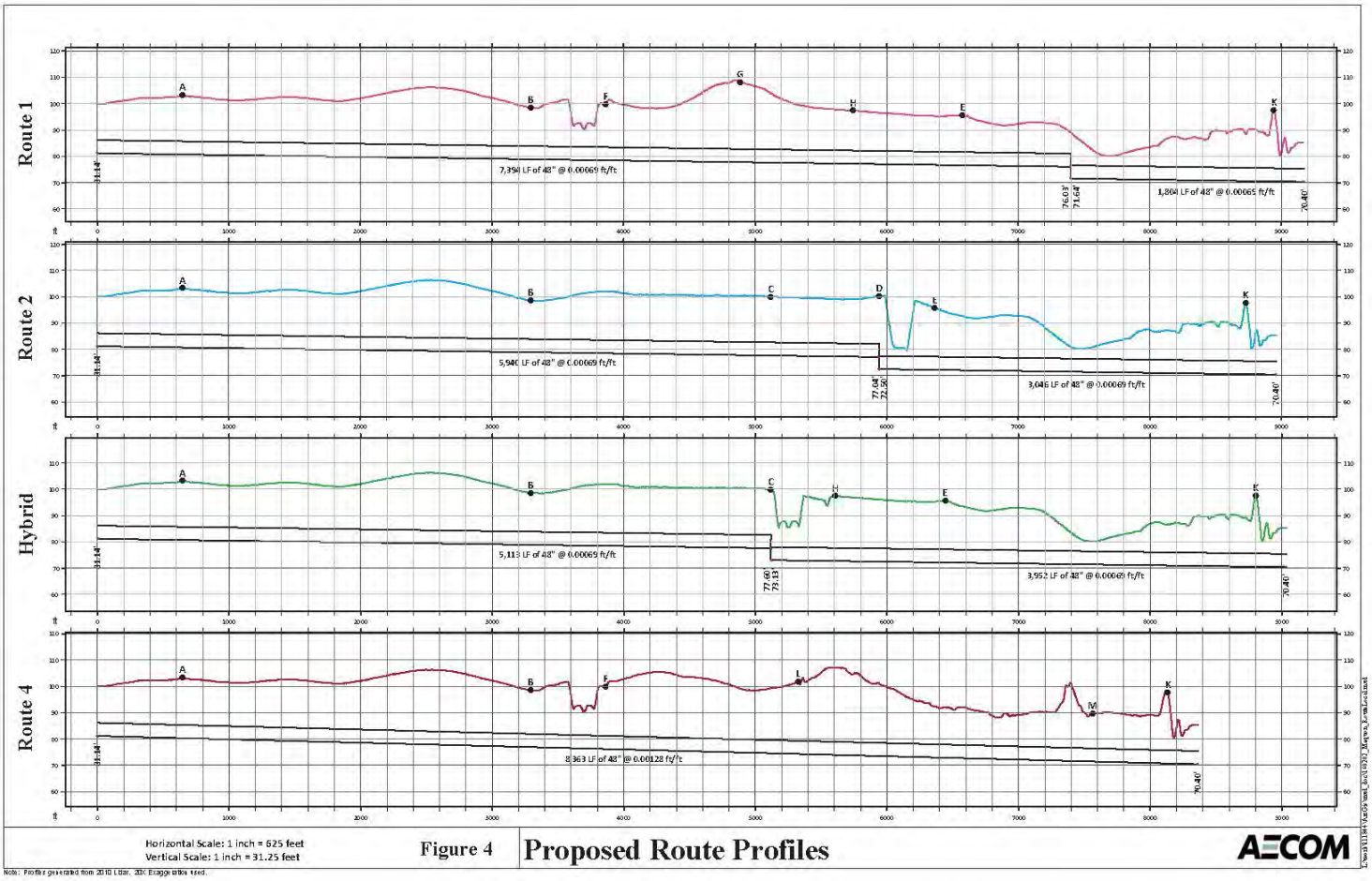
N W E S

AECOM

L:\work\111844\ArcGis\mxd_doc\160202_Mequon_Sewer.mxd

Source: Mequon 2011, MMSD 2006, Wisconsin DNR, NWI

Figure 4 – Proposed Route Profiles



Evaluation Criteria – The paired-comparison analysis method requires that a variety of criteria to properly represent the alternative routes are identified and defined to use in the evaluation. The following list identifies and defines the evaluation criteria:

- **Environmental Impacts** - Impacts to the constructability of a given alternative based on the locations of existing environmental contamination, wetlands and forestation.
- **Traffic Disruption** - Impacts to traffic flows resulting from construction of a given alternative.
- **Construction Impacts** - Impacts to public and private concerns resulting from the construction of a given alternative.
- **Ease of Access/Maintenance** - Measure of the advantages of a given alternative in terms of the ease with which the alternative can be accessed and maintained.
- **Easement Requirements** - Measure of the surface area required by private property easement acquisition to construct a given alternative.
- **Worker Safety** - Measure of the relative safety of City workers performing their jobs to service the utility.
- **Storage Capacity** - Measure of the alternative to temporarily store excess wet-weather flow during and after a storm event.
- **Average Depth** - Measure of pipe depth (ft) from surface to invert elevation averaged along the route alignment from the intersection of Port Washington Road and Zedler Lane to the District connection point.
- **Utility Conflicts** - Measure of the relative degree to which buried and overhead utilities affect the construction of a given alternative. Assumes roadway centerline relief sewer location where applicable.

It is important to note that the City also required AECOM to consider the deleterious effects of hydrogen sulfide gas and other deterioration factors in the evaluation. However, the preliminary engineering phase has not yet determined final elevations, structural configurations and operational characteristics. Therefore, it is felt that the rank of all alternatives would remain unchanged with its inclusion in the evaluation so it was not considered at this point but will be discussed in general later in this report.

Utilizing the above list, the design team compared each criterion with every other criterion in the analysis, one at a time, to determine its relative importance. A numerical ranking of 1–3 was assigned to each preferred (more important) criterion, using 1 as a slight preference, 2 as a medium preference and 3 as a strong preference. The summation of preference points for each criterion results in the “Paired Score" in the Alternative Evaluation Matrix. The matrix also includes an arbitrary “Minimum Score” value of 3 to demonstrate that low-preference criteria still have some bearing in the evaluation. The “Total Score” is the sum of the Paired and Minimum Scores. This process was used to create a weighting factor. All criteria were weighted and normalized to 100 for use in the evaluation matrix.

The Evaluation Matrix requires determinations of the 50-year life-cycle cost (LCC), predicated on opinion of probable construction cost and 20-year simple present worth (SPW). Explanations of the SPW and LCC methods are presented in the memorandum entitled *Methods Used for AECOM Present Worth Cost Calculations* in Appendix E. The evaluation of each alternative was completed by ranking each criterion with a score of 1-10, with 1 representing the least ability to achieve the associated criterion and 10 representing the most ability to achieve the associated criterion. Applying the weighting factors and summing the results yields a total weighted criterion representing "value points". Dividing the value points by the 50-year LCC yields a "value index" representing the number of value points for each dollar spent. The included alternatives were then ranked by value index with the highest index ranking first.

Presentation of Criteria – To the extent possible, AECOM objectively quantified criteria to expedite the evaluation process by assigning numerical values based on project investigation. Potential environmental impact sites, tabulated below, have also been located graphically in Figure 3, which was used as a reference document during the route analysis of the proposed 48-inch diameter relief sewer.

Environmental Contamination - AECOM accessed the open and closed Remediation and Redevelopment (RR) sites from the Wisconsin Department of Natural Resources' Bureau for Remediation and Redevelopment Tracking System (BRRTS) on the Web to locate potential environmental concerns for the ETS and EGA sewer alignments identify potential construction impacts along each included alternative route. A more detailed accounting of environmental impacts will be presented in the *Phase I Hazardous Materials Assessment*, located in Appendix F.

Compilation of data for traffic impacts, land acquisition/easements, computed storage capacities and average depths is presented in Table 2 – Objective Criteria.

Table 2 – Objective Criteria

Alternative Route No.	Length	No. of Potential Env. Sites	Weighted Traffic Count*	Required Easement Area (square ft)**	Storage Capacity (gallons)	Average Depth (ft)
1	5,905	3	3,483	56,244	555,070	18.7
2	5,693	1	1,881	28,184	535,142	20.1
3	Route 3 was removed from further consideration as discussed later in this report.					
4	5,070	2	415	28,300	476,580	22.8
Hybrid 2-3-1	5,772	1	2,874	19,884	542,568	19.2

* Weighted measure of relative traffic volume distributed over the various roadways of a given alternative route.

Local traffic counts obtained from State of Wisconsin Department of Transportation for principal and minor arterial roads. Local road counts assumed by AECOM traffic engineer. Weighted traffic count computed as follows:

Weighted Traffic Count:

$$= \frac{(\text{Road Length 1} * \text{Traffic Count 1}) + (\text{Road Length 2} * \text{Traffic Count 2}) + \ldots + (\text{Road Length n} * \text{Traffic Count n})}{\sum_{n}^{n=1}(\text{Road length})}$$

** Assumes 20-ft wide acquired easement and 11-ft additional width to existing easements.

Utility location sources obtained from municipal and private utility companies have been compiled in Table 3 – Potential Utility Conflicts.

Table 3 – Potential Utility Conflicts

Alternative Route No.	Fiber Optics	AT&T	Electric	Gas	Time Warner Cable (TWC)	Sanitary Sewer	Storm Sewer	Water	Total Utilities Count
1	4	1	5	3X, 1A	1 OH	1	9	3	28
2	2	8X, 1A	5	2X, 1A, H.P.	1 OH	2	12	2	36
3	Route 3 was removed from further consideration as discussed later in this report.								
4	4	1X, 1A	0	1	1 OH	4	3	1	16
Hybrid 2-3-1	0	3	6	2X, 1A, H.P.	1 OH	2	13	2X, 1A	31

Note: Potential conflict assumes relief sewer alignment is centerline of roadway
"X" indicates utility crosses the proposed alternative relief sewer
"A" indicates utility runs adjacent within approximately 10 feet of the proposed alternative relief sewer
"OH" designates overhead (aerial) utility
"H.P." designates high-pressure gas main
Uncharacterized utility values assumed to cross the proposed alternative relief sewer

AECOM has also computed an estimate of the excavation volume required along the evaluated portions of each included alignment alternative even though not a formal evaluation criterion, which is presented here for information. This value was determined assuming an 11-ft wide (tight-sheeted) trench at the associated average route depth over the associated evaluated route length. The resulting estimated excavation volumes are indicated in Table 4 - Estimated Excavation Volume.

Table 4 – Estimated Excavation Volume

Alternative Route No.	Length (ft)	Average Depth (ft)	Maximum Depth (ft)	Required Excavation (CY)
1	5,905	18.7	31.0	44,987
2	5,693	20.1	27.9	46,619
3	Route 3 was removed from further consideration as discussed later in the report.			
4	5,070	22.8	33.3	47,095
Hybrid 2-3-1	5,772	19.2	26.9	45,150

The remaining criteria required local input from City staff to evaluate subjectively:

- Construction Impacts - Impacts to public and private concerns resulting from the construction of a given alternative.
- Ease of Access/Maintenance - Measure of the advantages of a given alternative in terms of the ease with which the alternative is accessed and maintained.
- Worker Safety - Measure of the relative safety of City workers performing their jobs to service the utility.

Performance of Paired Comparison Analysis – The Design Team and City of Mequon Staff performed a paired comparison analysis on March 22, 2016 for Routes 1, 2, 4 and a Hybrid Route consisting of portions of Routes 2, 3 and 1. Route 3 was initially identified as a potential alignment to intercept a siphon sewer below the ravine at Heritage Court extended west of Courtland Drive along the route to the District's connection point. After checking the hydraulics and available drop, it was determined that the invert of the alignment would protrude approximately six feet above the invert of the ravine in order to drain by gravity to the District's sewer. Route 3 was therefore considered not feasible and eliminated from further consideration and not used in this route evaluation for these reasons.

The Hybrid Route is a combination of Routes 2, 3 and 1 and was designed to take advantage of the higher I-43 crossing elevation versus Route 2, allowing greater crossing clearance and additional drop to the outlet. This route also benefits from the shallowest maximum depth and avoids the deeper excavations required of Routes 1 and 4.

Paired Comparison Analysis Results – Based on the City's input, criteria weighting factors were determined and presented in Table 5 – Criteria Weighting Matrix.

Table 5 – Criteria Weighting Matrix

Table 5
Weighting Criteria Matrix

	B	C	D	E	F	G	H	I	Evaluation Criteria	Paired Score	Minimum Score	Total Score	Weighting Factor
A	A2	C3	D3	E3	F3	G3	A2	I3	Environmental Impacts	4	3	7	5.93
	B	C2	D1	E1	F3	G2	H1	I3	Traffic Disruption	0	3	3	2.54
		C	D2	C2	F3	G2	C2	I3	Construction Impacts	9	3	12	10.17
			D	D3	F3	G3	D3	I2	Ease of Access/Maintenance	12	3	15	12.71
				E	F3	G3	E3	I2	Easement Requirements	7	3	10	8.47
					F	F3	F3	F3	Worker Safety	24	3	27	22.88
						G	G3	I2	Storage Capacity	16	3	19	16.10
							H	I3	Average Depth	1	3	4	3.39
								I	Utility Conflicts	18	3	21	17.80
											27	118	100

KEY

Evaluation Criteria are the project elements or alternatives that need to be compared:

A - Environmental Impacts - Impacts to the constructability of a given alternative based on the locations of existing environmental contamination, wetlands and forestation.

B - Traffic Disruption - Impacts to traffic flows resulting from construction of a given alternative.

C - Construction Impacts - Impacts to public and private concerns resulting from the construction of a given alternative.

D - Ease of Access/Maintenance - Measure of the advantages of a given alternative in terms of the ease with which the alternative is accessed and maintained.

E - Easement Requirements - Measure of the surface area required by private property easement acquisition to construct a given alternative.

F - Worker Safety - Measure of the relative safety of City workers performing their jobs to service the utility.

G - Storage Capacity - Measure of the alternative to temporarily store excess wet-weather flow during and after a storm event.

H - Average Depth - Measure of pipe depth (ft) from surface to flow line elevation averaged along the route alignment from intersection Pt. Washington Rd. & Zedler Ln. to outfall.

I - Utility Conflicts - Measure of the relative degree to which buried and overhead utilities affect the construction of a given alternative. Assumes roadway centerline relief sewer location.

Score is the total number of points for each attribute

Weighting Factor is the relative numerical value of each attribute

Ranking

1 = Slight Preference

2 = Medium Preference

3 = Strong Preference

As could be expected, Worker Safety was considered paramount and weighted most heavily at 22.88%. The next two most preferred criteria were Utility Conflicts at 17.80% due to potential significant costs and Storage Capacity due to project purpose and need at 16.10%. Traffic Disruption was considered by the City to be a temporary concern that could be managed during construction only and was weighted least at 2.54%.

The criteria weighting factors were incorporated into Table 6 – Alternative Ranking Matrix and the four included alternative routes were analyzed by applying ranking values to the criteria.

Table 6
Alternative Ranking Matrix

Evaluation Criteria		Route 1		Route 2		Route 4		Hybrid Route 2-3-1	
		Port Wash. Rd - Zedler Katherine - Co. Line Rd.		Port Wash. Rd - Pt Wash. Ln Co. Line Rd.		Port Wash. Rd - Zedler Easement along RR - Co. Line Rd.		Port Wash. Rd/Ln - El Rancho @ I43 - Pt. Wash Rd. - Co. Line Rd.	
	Weight	Rating	Score	Rating	Score	Rating	Score	Rating	Score
Environmental Impacts	5.93	*7*	42	*10*	59	*1*	6	*10*	59
Traffic Disruption	2.54	*7*	18	*1*	3	*10*	25	*4*	10
Construction Impacts	10.17	*1*	10	*4*	41	*10*	102	*4*	41
Ease of Access/Maintenance	12.71	*1*	13	*1*	13	*1*	13	*1*	13
Easement Requirements	8.47	*1*	8	*4*	34	*7*	59	*10*	85
Worker Safety	22.88	*1*	23	*1*	23	*10*	229	*1*	23
Storage Capacity	16.10	*10*	161	*4*	64	*1*	16	*7*	113
Average Depth	3.39	*4*	14	*4*	14	*4*	14	*4*	14
Utility Conflicts	17.80	*1*	18	*1*	18	*10*	178	*7*	125
Total Weighted Criteria	100.0	306		268		642		481	
Construction Capital Cost		$7,461,000		$7,206,600		$7,243,000		$7,301,400	
Non- Construction Cost		$2,238,300		$2,161,980		$2,172,900		$2,190,420	
Evaluated Route Project Capital Cost		$9,699,300		$9,368,580		$9,415,900		$9,491,820	
20-yr Simple Present Worth Cost		$7,828,710		$7,575,550		$7,734,275		$7,674,888	
50-yr Life Cycle Cost		**$10,385,090**		**$10,078,910**		**$10,435,747**		**$10,210,237**	
Value Ratio (Value Points / 50-year LCC)		**29**		**27**		**61**		**47**	
Rank		**3**		**4**		**1**		**2**	

P:\60288274\400_Technical\425_Alternatives Evaluation (Paired-Comparison Analysis)\Evaluation Matrices\[Draft Alternative Eval and Rank.xlsx]Objective Criteria Summary

KEY

Evaluation Criteria are the project elements or alternatives from Table X-x
Score is the total number of points for each criteria calculated by multiplying the rating by the weight
Weight is the relative numerical value of each evaluation criteria from Table X-x

Rating
1 = Least Ability to Achieve Criteria
10 = Most Ability to Achieve Criteria

AECOM

The four alternatives were rated according to their ability to achieve the criteria under consideration. Ranking reasoning of the criteria for the alternative routes is briefly discussed below:

Environmental Impacts - Route 2 and the Hybrid route were rated highest to achieve criteria with the lowest number of potential environmental sites. Although both Routes 1 and 4 had a higher number of potential environmental sites, Route 4 was rated least able to achieve criteria due to environmental concerns such as tree removal and the required access roadway in the parkway.

Traffic Disruption – Route 2 and the Hybrid route were rated poorly in part by traffic access on Port Washington Lane. Route 1 had fewer access problems and rated higher than Route 2 or the Hybrid route and Route 4 rated highest due to very little traffic overall.

Construction Impacts – The City of Mequon is very sensitive to the needs and inconveniences of the community. Route 1 would impact a large number of residents in and near Heritage Estates and was rated worst of the alternatives. Route 2 and Hybrid route also impact a large number of residents and were also rated poorly. Due to the remote location of Route 4 and minimum residential impacts, the alternative was rated highest and accounted for the third highest criterion score.

Ease of Access/Maintenance - None of the four alternatives was considered able to achieve Ease of Access/Maintenance due to traffic concerns, dense forest and shrub cover, fences, uneven terrain and access challenges through the parkway. Therefore, all routes were rated 1.

Easement Requirements – Ratings for Easement Requirements were based on the actual square footage needed to accommodate the alternative routes and the number of property owners that would require agreements. Although Route 2 required slightly less square footage than Route 4, it also had ten prospective property owners versus nine for Route 4. Therefore, Route 4 rated second best for achieving the criterion. The Hybrid route ranked highest and Route 1 ranked lowest in the category.

Worker Safety – Worker safety was largely dependent on traffic volumes of the alternative routes. Since Routes 1, 2 and the Hybrid route all had weighted traffic counts ranging between approximately 1,900 and 3,500 vehicles per day versus 415 for Route 4, all but the latter were rated 1 and the latter rated 10.

Storage Capacity – Since storage capacity is a function of route length, the ratings directly followed the length; Route 1 was given the highest rating and Route 4 the lowest.

Average Depth – Although average depth could be a reasonable indication of constructability, the depth difference only ranged four feet from approximately nineteen to twenty three feet. Since all of these depths require ground support and pose difficulty in construction, all routes were rated “4”.

Utility Conflicts – Routes 1, 2 and the Hybrid route all had total utilities counts ranging from 28 to 36. Routes 1 and 2 were given ratings of 1 due to higher fiber optic encounters and the Hybrid route rated 7 with no fiber optic counts; however, even though Route 4 had some fiber optic counts, the overall count was lowest and therefore rated 10.

In summary, significant Route 4 criteria scores for worker safety and utility conflicts accounting for 63% of the Total Weighted Criteria contributed to the highest Value Ratio in spite of the highest 50-year life cycle cost and resulted in the number one ranking. These results are based on the current Paired Comparison Analysis completed with the City on March 22, 2016. Although criteria ratings might change as the City evaluates physical attributes in the field and required agreements with property owners as well as other jurisdictional agency requirements, Route 4 will be considered the recommended alternative route for in the remainder of this Preliminary Engineering Report.

2.6 Phase I HMA results and discussion

AECOM conducted a Phase 1 Hazardous Materials Assessment (Phase 1) for the City of Mequon for an alternatives analysis of the EGA and East Trunk Relief Sewer improvements in the City of Mequon, Ozaukee County. The approximately 4.5-mile long corridor begins near Highland Avenue to the north and ends to the south near the railroad and County Line Road extended.

The purpose of the Phase 1 was to identify sites that have known or potential hazardous materials concerns within and adjacent to the project limits. The work was performed in general accordance with Procedure 21-35-5 of the WisDOT Facilities Development Manual.

The Phase 1 Investigation consisted of a field reconnaissance, a review of federal and state regulatory agency databases, a review of historic documents, interviews, and a review of topographic, geologic, and groundwater mapping.

As a result of the assessment, twenty-nine sites with known and potential hazardous materials concerns were identified within and adjacent to the project area. These sites are identified and located in detail in Appendix Site Location Maps of Appendix F Phase I HMA. Based on the configuration and character of these sites, twenty four of them required no further hazardous materials investigation or site specific special provisions. The other five sites are discussed as based on their relative concerns.

Because of the known nature of the extent of the contamination at the following sites, it is recommended that special provisions be prepared to notify the contractor of potential soil and ground water impacts associated with these sites and be included in the project special provisions. If excavation is planned in areas of known contamination, excavated impacted material will require proper testing, handling and disposal.

- Curros Amoco Food Shop – 11147 North Port Washington Road
- Intersection of North Port Washington Road and Mequon Road
- Park Avenue Bigelow Property – 10012-10020 North Port Washington Road

Because of the documented presence of soil and groundwater contamination in North Port Washington Road adjacent to the following sites, it is recommended that Phase 2 investigations be conducted to determine if the impacted media will adversely affect the proposed project:

- Mobil Oil Corp – 11210 North Port Washington Road
- Clark Oil Station #364 – 10355 North Port Washington Road

2.7 Additional Design Considerations

Discussion of provisions for H_2S resistance – Hydrogen sulfide corrosion typically occurs where turbulent flow causes release of H_2S gas in anaerobic wastewater with dissolved sulfide. The gas combines with moisture on the non-submerged surfaces of the pipe and is oxidized to sulfuric acid by anaerobic bacteria. Hydrogen ions in the sulfuric acid attack the calcium hydroxide in the hydrated Portland cement, damaging the concrete. Turbulence causing H_2S generation is affected by sewer slope and velocity, which in turn affects degree of reaeration and solids deposition. Surcharging reduces oxygen transfer and promotes sulfide generation. Although the concrete pipe cannot corrode under surcharged conditions, it will occur as flow levels drop. Presence of force mains and inverted siphons trigger the same effects as surcharging, releasing hydrogen sulfide gas at the turbulent discharge end.

Release of hydrogen sulfide gas can be reduced by addition of oxidants, precipitants or pH elevators to the wastewater streams in force mains and gravity sewers, thereby reducing corrosive agents.

Gravity sewers should be designed to provide cleansing velocities and detention times should be minimized wherever possible. Construction for new pipe systems should specify corrosion resistant pipe materials such as PVC, PE and centrifugally cast, fiberglass-reinforced, polymer mortar (CCFRPM) pipe such as Hobas or concrete pipe with similar linings. Junction structures, manholes, etc. should be designed to minimize turbulence and release of H_2S and consideration should be given to air/oxygen injection or chemical addition stations where appropriate.

Configuration of Trunk/Relief Sewers Interconnections – Interconnectivity between the trunk sewer and the relief sewer must be carefully considered to optimize use of the relief sewer. To avoid low flows and the resulting sub-scour velocities, wet-weather diversion through an actively or passively managed diversion structure(s) should only occur after the HGL in the trunk sewer achieves a minimum pre-determined level. The diversion configuration, rate, structure dimensions and elevations will be determined in final design.

Permits – Estimated permits required for the proposed construction include but may not be limited to the following listing and as noted.

- Union Pacific Railroad Company Permit
- DOT ROW Work Permit
- DOT ROW Utility Permit
- DNR Sewer Permits – 3400-059, 3400-095, 3400-160, 3400-168, 3400-205
- DNR Storm Water NOI
- DNR Dewatering Permit (maybe contractor)
- Ozaukee County Highway Permit (depends on who controls the road)
- Regional Planning Commission Approval Letter

- Milwaukee Metropolitan Sewerage District

The District uses a sewer plan review process which provides a means for them to ensure compliance with their required rules and regulations, including I/I and Capacity, Management, Operation & Maintenance (CMOM) Program. The Sewer Plan Review Submittal Toolkit, as it is referred to on their website http://www.mmsd.com/rulesandregs/community-exchange, can be followed to properly prepare plans for submittal and other general requirements governing the submittal of plans. The site also includes required forms and cover letters to expedite WDNR review.

Identify Options for Phasing Implementation and Construction – AECOM has considered the schedule for implementing and phasing construction activities to optimize realized benefits as early in the construction phase as possible. Table 7 – Implementation and Construction Phasing identifies various components of the improvement project and the benefits gained by construction of the associated component.

Table 7 - Implementation and Construction Phasing

Project Component	Benefit Realized by Construction
48-inch Diameter Relief Sewer	Overall system surcharging relief and localized relief to Brookdale Drive and Clover Lane bypass pumping
Hidden Reserve Subdivision Trunk Sewer Enlargement	Localized relief to sewer surcharging and basement backups through the Hidden Reserve neighborhood
EGA Lift Station and Force Main	Required to implement Lift Station F force main rerouting
Rerouting of Lift Station F Force Main to EGA Lift Station	Relief to aging Lift Station E infrastructure and additional relief to Hidden Reserve trunk sewer
EGA Gravity Sewer	Ability to service future development of East Growth Area

Completion of the relief sewer construction will allow the ETS to convey flows up to and including those generated during the storm event of June 17-18, 2014 without problematic surcharging, thereby reducing the likelihood of basement backups and bypass pumping. The relief sewer will also provide increased capacity to service a larger trunk sewer through Hidden Reserve, further reducing chances of basement backups through that subdivision.

Completion of the EGA Lift Station and force main is required prior to relocating the Lift Station F force main to reduce pumping demands on the aging infrastructure at Lift Station E, thereby reducing the potential for surcharging and the need to bypass at Lift Station E. This force main relocation will improve the overall level of service for the East Trunk Sewer system and the localized system tributary to Lift Station E.

Completion of the EGA Lift Station will allow construction of a gravity sewer to service the area and provide for future development. Construction of the gravity line to the proposed lift station can be phased to coincide with the commencement of development.

2.8 20-year Simple Present Worth (SPW)/50-yr Life-Cycle Costing (LCC) for Alternative Route 4

The opinion of probable construction cost of the complete recommended alternative Route 4, including the EGA Lift Station, associated force main and gravity sewer, Lift Station F force main relocation, and reconstruction of the Hidden Reserve Subdivision trunk sewer is $18,699,675. The associated engineering, legal and administrative costs (30%) are $5,609,903, resulting in a total project cost of $24,309,578. The source of these costs can be referenced in the *Alternative Construction Costs* spreadsheet in Appendix G.

The 20-year SPW and 50-year LCC is calculated in a spreadsheet entitled *Mequon East Trunk Relief Sewer 20-yr & 50-yr Life Cycle Costs* in Appendix H. In addition to the construction and non-construction costs, the calculation also requires an estimate of the Operations and Maintenance over the service life of the facility. Recurring costs for annual and longer duration recurrences have been estimated based on information from the City of Mequon Public Work/Engineering Department as presented in the *Mequon Lift Station Maintenance Basis* memo in Appendix I as well as AECOM and local sewer cleaning and televising service companies.

Costs were estimated as follows:

Annual cleaning costs for the 48-inch diameter relief sewer are based on		
$3/LF x 8,363 LF		= $25,089
Assumed annual maintenance costs for the East Growth Area Lift Station		= $26,700
	Total annual costs	= $51,789
5-year recurring costs for sewer televising are based on	$2/LF x 8,363 LF	= $16,726
5-year recurring costs for Route 4 access road maintenance:	$30/LF x 2,000 LF	= $60,000
	Total annual costs	= $76,726
	Annual equivalent	= $15,345
15-year recurring East Growth Area Lift Station pump replacement cost:		
Replace 3 submersible pumps at $20,000 ea + 15% installation:	(3 x $20,000) + 15%	= $69,000
	Annual equivalent	= $ 4,600
	Cumulative annually recurring	= $71,734

As presented in Appendix H, the resulting 20-year SPW is $19,863,214 and the 50-year LCC is $26,596,882.

2.9 Recommendations

During the initial screening process, the City of Mequon reviewed seven markedly different hydraulic relief alternatives and agreed to move forward with a “hybrid” alternative incorporating elements from Alternatives 3 and 6. Furthermore, they desired some additional components to provide an increased level of protection to Lift Station E. These components included increased capacity for Hidden Reserve subdivision where a significant concentration of properties experience basement backups during wet-weather events, capacity for the East Growth Area and moderation of the pumping demands on the aging infrastructure of Lift Station E.

Provisions for these issues were incorporated into the hybrid alternative identified as Alternative 6a discussed earlier in this report. Following the presentation of Alternative 6a to the City of Mequon Sanitary Utility District Commission on September 22, 2015 and their unanimous approval for authorization to pursue the alternative 6A evaluation of a final alignment for the lower portion of the relief sewer.

As discussed earlier, the paired comparison analysis performed to document the optimum alternative returned Alternative 4 along Zedler Lane and through Katherine Kearney Carpenter Park to the District connection as the preferred alignment.

As currently configured, Alternative Route 4 requires construction of the following elements:

- 8,363 LF of 48-inch diameter corrosion resistant relief sewer pipe
- 21 relief sewer manholes at 400 ft spacing
- 1,615 LF of 12-inch diameter gravity sewer serving the EGA
- 5 EGA gravity sewer access manholes at 400 ft spacing
- EGA Lift Station
- 14,285 LF of 18-inch diameter force main from EGA Lift Station to relief sewer
- 3,080 LF of 12-inch diameter force main rerouted from Lift Station F to EGA Lift Station
- Abandon approximately 769 LF of existing 10-inch Lift Station F force main terminating at ETS manhole no. 0118-095
- Replace 421 LF of 18-inch diameter trunk sewer with 24-inch diameter trunk sewer
- Replace 2,792 LF of 24-inch diameter trunk sewer with 27-inch diameter trunk sewer
- 9 trunk sewer access manholes at 400 ft spacing

3.0 Conclusion

Route 4 of Alternative 6a provides hydraulic protection against a storm of magnitude up to and including that of June 17-18, 2014 for the trunk sewer system. Due to the incorporated enhancements desired by the City, it also provides increased sanitary flow capacity for the Hidden Reserve subdivision where a significant concentration of properties experience basement backups during severe wet-weather events. A secondary benefit of the increased capacity afforded by the enlarged trunk sewer replacement is decreased infiltration and inflow and a resulting decrease in wet weather flows. The project includes capacity for the East Growth Area and the resulting ability to accommodate new development and an expanded tax base. Lastly, the project will reduce pumping demands on the aging infrastructure of Lift Station E due to the diversion of flows from Lift Station F to the proposed relief sewer. Construction of this relief sewer system should result in reduced surcharging and a lower frequency of bypass pumping requirements for storms that do not exceed the design recurrence interval.

Route 4 of Alternative 6a provides a solution that is cost effective and accomplishes the many goals of this project. It is documented by the paired comparison analysis as providing the most value to the City per dollar spent and it is recommended that the City move forward with the intent of this preliminary design. Routes 1, 2 and the Hybrid Route also provide valid alternatives for consideration in the design phase.

It is important to note that even with the system improvements as discussed, it is possible the City may need to provide bypass pumping in various locations in the ETS, potentially at Lift Station E and at Brookdale Drive and Clover Lane under storm events that are larger than that which the modeled flows and design are capable of conveying and storing. Additionally, there may still be bottlenecks or other conditions in the collection system in the ETS associated with the EGA that has other issues that are not known or being addressed directly as part of this project and localized conditions may still result in some locations experiencing basement backups.

Because there can (and always will be) more significant events that the system is not capable of conveying or storing, the City should and will continue with strategic I/I reduction activities on both the private and to the extent possible, public side to improve the current and future system performance.